PUBLIC LECTURE SERIES

Olbers' Paradox and Gravitational Light Deflection

Featuring Guest Speaker:
Kelsey Glazer

1
00:00:04,519 --> 00:00:01,250
good evening ladies and gentlemen and

2
00:00:07,099 --> 00:00:04,529
welcome to the Space Telescope public

3
00:00:08,750 --> 00:00:07,109
lecture series I am dr. Frank summers of

4
00:00:10,850 --> 00:00:08,760
the office of public outreach and it is

5
00:00:13,640 --> 00:00:10,860
my pleasure and joy to welcome you here

6
00:00:16,250 --> 00:00:13,650
each and every month and when you come

7
00:00:18,529 --> 00:00:16,260
in there are lithographs tonight's

8
00:00:20,480 --> 00:00:18,539
lithograph chosen by our speaker because

9
00:00:23,570 --> 00:00:20,490
she will mention it in her talk is the

10
00:00:25,880 --> 00:00:23,580
extreme deep field you want to know what

11
00:00:29,359 --> 00:00:25,890
that means turn over we get about 300

12
00:00:32,060 --> 00:00:29,369
words describing this Hubble observation

13
00:00:35,930 --> 00:00:32,070

that was released like 2011 2012

14
00:00:38,090 --> 00:00:35,940
timeframe and all of the thousands of

15
00:00:40,940 --> 00:00:38,100
galaxies that you are seeing in the

16
00:00:43,760 --> 00:00:40,950
extreme deep field our speaker tonight

17
00:00:45,770 --> 00:00:43,770
is Kelsey Glaser from Towson University

18
00:00:50,420 --> 00:00:45,780
and she'll be speaking on Olbers paradox

19
00:00:54,439 --> 00:00:50,430
and gravitational light deflection next

20
00:00:57,380 --> 00:00:54,449
month we have a special date okay we

21
00:00:59,599 --> 00:00:57,390
usually skip the day after New Year's it

22
00:01:02,330 --> 00:00:59,609
would have been January 2nd and people

23
00:01:04,160 --> 00:01:02,340
are tend to tend to be otherwise engaged

24
00:01:05,929 --> 00:01:04,170
at that time so we usually skip that and

25
00:01:08,090 --> 00:01:05,939
then we're going to put it on January

26
00:01:10,910 --> 00:01:08,100
9th but the American Astronomical

27
00:01:14,090 --> 00:01:10,920
Society meeting is in Washington DC this

28
00:01:16,219 --> 00:01:14,100
year so lots of people from this

29
00:01:18,740 --> 00:01:16,229
building will be down in DC it's very

30
00:01:20,899 --> 00:01:18,750
hard to get a speaker for January 9th so

31
00:01:23,510 --> 00:01:20,909
at the speakers request I moved it to

32
00:01:25,880 --> 00:01:23,520
January 16th okay so not the first

33
00:01:28,760 --> 00:01:25,890
Tuesday not the second Tuesday but the

34
00:01:30,980 --> 00:01:28,770
third Tuesday next month is one of the

35
00:01:32,960 --> 00:01:30,990
few times I've ever done that okay but

36
00:01:35,929 --> 00:01:32,970
it's worth coming to see because it will

37
00:01:39,499 --> 00:01:35,939
be web in three acts the telescope the

38
00:01:41,749 --> 00:01:39,509

science the legacy and it's such a big

39
00:01:45,289 --> 00:01:41,759
topic we have three not one not two but

40
00:01:48,039 --> 00:01:45,299
three speakers for you Nicole Lewis

41
00:01:51,499 --> 00:01:48,049
Bonnie Meinke and Klaus pontoppidan

42
00:01:54,740 --> 00:01:51,509
we'll be giving you the lowdown on the

43
00:01:58,850 --> 00:01:54,750
next great Observatory the James Webb

44
00:02:00,709 --> 00:01:58,860
Space Telescope in February we will have

45
00:02:05,060 --> 00:02:00,719
Hannah Wickford and she'll be talking on

46
00:02:07,429 --> 00:02:05,070
the wildest weather in the universe and

47
00:02:09,859 --> 00:02:07,439
that will be a talk on the weather on

48
00:02:12,470 --> 00:02:09,869
extrasolar planets not planets in our

49
00:02:13,580 --> 00:02:12,480
solar system the planets outside our

50
00:02:16,190 --> 00:02:13,590
solar system

51
00:02:18,860 --> 00:02:16,200
for information on this and other talks

52
00:02:20,920 --> 00:02:18,870
we go to our web page go to your

53
00:02:23,809 --> 00:02:20,930
favorite search engine and put in Hubble

54
00:02:26,690 --> 00:02:23,819
Space Telescope public talks you'll find

55
00:02:28,580 --> 00:02:26,700
this webpage where we have a link the

56
00:02:31,220 --> 00:02:28,590
the descriptions of the upcoming

57
00:02:34,640 --> 00:02:31,230
lectures we have a link to watching it

58
00:02:38,390 --> 00:02:34,650
on YouTube and our webcasting site we

59
00:02:40,970 --> 00:02:38,400
have past lectures back to 2005 and you

60
00:02:43,580 --> 00:02:40,980
can subscribe to our email list for

61
00:02:45,979 --> 00:02:43,590
announcements we've actually gotten like

62
00:02:50,030 --> 00:02:45,989
almost 600 people on our announcements

63
00:02:50,870 --> 00:02:50,040

list it's it's kind of nice we have if

64
00:02:53,630 --> 00:02:50,880
you would like to sign up for the

65
00:02:56,509 --> 00:02:53,640
announcements I this seems duplicitous

66
00:02:59,000 --> 00:02:56,519
because I do play duplicate because you

67
00:03:01,640 --> 00:02:59,010
know I just said it but anyways sign up

68
00:03:03,350 --> 00:03:01,650
at the websites easiest or if you don't

69
00:03:05,420 --> 00:03:03,360
like doing that you can just provide

70
00:03:08,539 --> 00:03:05,430
your email address to me and I will make

71
00:03:09,920 --> 00:03:08,549
sure you get on it if you have comments

72
00:03:12,680 --> 00:03:09,930
or questions you can send it to this

73
00:03:16,819 --> 00:03:12,690
email address public lecture at stsci

74
00:03:19,309 --> 00:03:16,829
dot edu if you like social media we are

75
00:03:22,400 --> 00:03:19,319
available on Facebook and Twitter and

76
00:03:24,379 --> 00:03:22,410
YouTube and Instagram and myself I do

77
00:03:27,440 --> 00:03:24,389
Facebook Google and Twitter every now

78
00:03:31,640 --> 00:03:27,450
and then and sometimes write blog posts

79
00:03:33,170 --> 00:03:31,650
on hubble site I spend too much my time

80
00:03:36,410 --> 00:03:33,180
working that I don't spend enough time

81
00:03:39,800 --> 00:03:36,420
social media oh well yeah there's only

82
00:03:42,890 --> 00:03:39,810
so much time in life right observatory

83
00:03:44,500 --> 00:03:42,900
the weather is not permitting now how

84
00:03:47,180 --> 00:03:44,510
many people were here last month and

85
00:03:50,000 --> 00:03:47,190
remember that the Maryland spacecraft

86
00:03:53,240 --> 00:03:50,010
servitor II closed for repairs they got

87
00:03:56,960 --> 00:03:53,250
the repairs done okay so it is back in

88
00:04:00,080 --> 00:03:56,970

business okay so even though we're not

89
00:04:03,949 --> 00:04:00,090
able to do it tonight it is available if

90
00:04:05,599 --> 00:04:03,959
you go to MD dot space grant o RG and

91
00:04:08,690 --> 00:04:05,609
click on the observatory they do have

92
00:04:11,270 --> 00:04:08,700
open houses on Fridays and see this

93
00:04:12,890 --> 00:04:11,280
Observatory status box over there that

94
00:04:14,900 --> 00:04:12,900
is where you will find out if you check

95
00:04:16,460 --> 00:04:14,910
on Friday afternoon Friday early Friday

96
00:04:20,210 --> 00:04:16,470
evening whether or not there will be

97
00:04:21,890 --> 00:04:20,220
open for observing that night okay so

98
00:04:25,250 --> 00:04:21,900
come support the Maryland Space Grant

99
00:04:27,460 --> 00:04:25,260
observatory and now our news from the

100
00:04:32,360 --> 00:04:27,470
universe for December 2

101
00:04:37,490 --> 00:04:32,370
2017 our first story tonight echoes of a

102
00:04:39,710 --> 00:04:37,500
dying star now we have had a very famous

103
00:04:43,300 --> 00:04:39,720
press release of over a bunch of years

104
00:04:45,920 --> 00:04:43,310
and involved the star v838 monocerotis

105
00:04:50,330 --> 00:04:45,930
okay or VA three eight month or short

106
00:04:51,890 --> 00:04:50,340
and this star witness in March of 2003

107
00:04:54,320 --> 00:04:51,900
this is a picture from the US Naval

108
00:04:56,450 --> 00:04:54,330
Observatory of a star going Nova and

109
00:04:57,710 --> 00:04:56,460
that basically means it brightened okay

110
00:05:00,320 --> 00:04:57,720
it had an explosion on the surface

111
00:05:02,720 --> 00:05:00,330
basically and it brightened okay the

112
00:05:06,380 --> 00:05:02,730
star did not explode but it just had a

113
00:05:09,440 --> 00:05:06,390

very event for the Nova now this became

114
00:05:12,680 --> 00:05:09,450
very famous in Hubble lore because the

115
00:05:14,810 --> 00:05:12,690
light from that explosion spread out

116
00:05:19,820 --> 00:05:14,820
across space and we watched it for

117
00:05:21,650 --> 00:05:19,830
several years so in May of 2003 here you

118
00:05:24,170 --> 00:05:21,660
can see the star in the center here has

119
00:05:26,480 --> 00:05:24,180
gone back to its normal state but the

120
00:05:29,090 --> 00:05:26,490
light is actually going through the dust

121
00:05:32,120 --> 00:05:29,100
clouds around it and illuminating those

122
00:05:34,900 --> 00:05:32,130
dust clouds and over the years as we

123
00:05:39,409 --> 00:05:34,910
watched it that that light expanded

124
00:05:49,730 --> 00:05:39,419
farther and farther into space so v838

125
00:05:52,040 --> 00:05:49,740
monocerotis the Nova went off at one

126
00:05:54,440 --> 00:05:52,050
point but because space is so big it

127
00:05:56,090 --> 00:05:54,450
takes years for that light to propagate

128
00:05:59,240 --> 00:05:56,100
out through the dust cloud around it and

129
00:06:00,190 --> 00:05:59,250
it illuminated different layers of that

130
00:06:04,040 --> 00:06:00,200
dust cloud

131
00:06:08,120 --> 00:06:04,050
now Nova happened in our galaxy we can

132
00:06:11,480 --> 00:06:08,130
observe them but supernovae are even

133
00:06:15,880 --> 00:06:11,490
bigger explosions and this for example

134
00:06:18,980 --> 00:06:15,890
is supernova 1987a where a star in here

135
00:06:21,500 --> 00:06:18,990
brightened up to be incredibly bright

136
00:06:24,350 --> 00:06:21,510
just brightened and basically becomes

137
00:06:27,890 --> 00:06:24,360
the brightest thing in a galaxy a very

138
00:06:31,490 --> 00:06:27,900

very short time we can see these across

139
00:06:33,950 --> 00:06:31,500
intergalactic distances so the light

140
00:06:37,670 --> 00:06:33,960
echo from a supernova should be

141
00:06:40,780 --> 00:06:37,680
observable and with Hubble we did

142
00:06:43,090 --> 00:06:40,790
observe it in the galaxy m82

143
00:06:44,950 --> 00:06:43,100
and you can see this cross here in the

144
00:06:48,040 --> 00:06:44,960
center okay that indicates where the

145
00:06:50,950 --> 00:06:48,050
supernova went off alright and the

146
00:06:54,760 --> 00:06:50,960
supernova went off and we started to see

147
00:06:57,820 --> 00:06:54,770
the light echo propagating around that

148
00:07:00,100 --> 00:06:57,830
supernova so from the distance of mm an

149
00:07:02,860 --> 00:07:00,110
82 we're able to see the supernova and

150
00:07:06,280 --> 00:07:02,870
then go back in and reprocess images

151
00:07:10,120 --> 00:07:06,290
taken by Hubble of m82 later to be able

152
00:07:13,450 --> 00:07:10,130
to pull out light echo from it alright

153
00:07:23,680 --> 00:07:13,460
so here is a video let me start it for

154
00:07:26,590 --> 00:07:23,690
you alright so this video is going to

155
00:07:27,580 --> 00:07:26,600
zoom into m82 that shows you the Big

156
00:07:32,380 --> 00:07:27,590
Dipper which is part of the

157
00:07:37,170 --> 00:07:32,390
constellation Ursa Major and just above

158
00:07:48,100 --> 00:07:37,180
are some Ager we'll pull into the galaxy

159
00:07:50,650 --> 00:07:48,110
Messier 82 and this is the Hubble image

160
00:07:52,870 --> 00:07:50,660
of M 82 and all that red is the H alpha

161
00:07:54,550 --> 00:07:52,880
emission from you know the starbursts

162
00:07:56,110 --> 00:07:54,560
and the center but we're not worried

163
00:07:58,660 --> 00:07:56,120

about that starburst in the center we're

164
00:08:02,110 --> 00:07:58,670
worried about one particular star that

165
00:08:04,750 --> 00:08:02,120
went supernova way down deep inside this

166
00:08:09,940 --> 00:08:04,760
galaxy yes see how far we have to zoom

167
00:08:12,490 --> 00:08:09,950
in in order to see this all right okay

168
00:08:17,290 --> 00:08:12,500
and here is a time-lapse of it sort of

169
00:08:20,980 --> 00:08:17,300
an animation of the explosion and we can

170
00:08:24,610 --> 00:08:20,990
process it to pull out the light echo so

171
00:08:27,490 --> 00:08:24,620
although that star has died it's light

172
00:08:30,120 --> 00:08:27,500
lives on echoing through the gas clouds

173
00:08:35,280 --> 00:08:30,130
around it for years afterwards

174
00:08:40,950 --> 00:08:35,290
that's kind of cool our second story

175
00:08:44,040 --> 00:08:40,960
rendezvous with drama well we had a

176
00:08:47,230 --> 00:08:44,050
interesting observation occur in October

177
00:08:48,880 --> 00:08:47,240
on October 19th I know this says October

178
00:08:52,600 --> 00:08:48,890
25th but that's when this graphic was

179
00:08:54,639 --> 00:08:52,610
was made on October 19th the pan-starrs

180
00:08:56,769 --> 00:08:54,649
one telescope

181
00:09:00,040 --> 00:08:56,779
observe what it thought was a comment

182
00:09:03,129 --> 00:09:00,050
and it gave it the provisional

183
00:09:05,710 --> 00:09:03,139
designation C 2017 you won

184
00:09:07,509 --> 00:09:05,720
well after just a little bit of study

185
00:09:10,239 --> 00:09:07,519
they could tell well there wasn't any

186
00:09:12,790 --> 00:09:10,249
coma around it so it can't be a comet

187
00:09:16,960 --> 00:09:12,800
must be an asteroid then it was given

188
00:09:19,119 --> 00:09:16,970

this designation a 2017 you want then

189
00:09:21,489 --> 00:09:19,129
after following it for a couple week or

190
00:09:24,809 --> 00:09:21,499
two they're able to determine an orbit

191
00:09:29,259 --> 00:09:24,819
for it and the orbit of this is

192
00:09:33,369 --> 00:09:29,269
hyperbolic which means it's not bound to

193
00:09:35,619 --> 00:09:33,379
the Sun okay it's on such a speedy orbit

194
00:09:37,419 --> 00:09:35,629
that it's going to escape the solar

195
00:09:39,400 --> 00:09:37,429
system it's coming through you can see

196
00:09:41,019 --> 00:09:39,410
it came through closer than the orbit of

197
00:09:45,119 --> 00:09:41,029
mercury and it's headed out it was

198
00:09:51,999 --> 00:09:45,129
actually discovered on its way out so

199
00:09:54,579 --> 00:09:52,009
this is a hyperbolic orbit which the

200
00:09:56,590 --> 00:09:54,589
simplest explanation for it is that it's

201
00:10:01,119 --> 00:09:56,600
not of this solar system that is

202
00:10:03,489 --> 00:10:01,129
actually interstellar in origin this has

203
00:10:06,699 --> 00:10:03,499
been touted as the first interstellar

204
00:10:09,549 --> 00:10:06,709
visitor to be observed now when we

205
00:10:10,989 --> 00:10:09,559
predict how many things from other solar

206
00:10:13,299 --> 00:10:10,999
systems should be passing through our

207
00:10:15,689 --> 00:10:13,309
solar system we say that there should be

208
00:10:18,429 --> 00:10:15,699
about tens to hundreds of these a year

209
00:10:20,439 --> 00:10:18,439
right but we've never seen one that we

210
00:10:22,360 --> 00:10:20,449
can say oh here is the out here is the

211
00:10:24,730 --> 00:10:22,370
observation that says yes this should be

212
00:10:26,799 --> 00:10:24,740
intercept it should be interstellar this

213
00:10:29,679 --> 00:10:26,809

is the first one okay the first

214
00:10:33,030 --> 00:10:29,689
interstellar visitor as people have been

215
00:10:36,040 --> 00:10:33,040
been want to call it so of course

216
00:10:38,530 --> 00:10:36,050
everybody who had a telescope was going

217
00:10:41,169 --> 00:10:38,540
out and looking at it okay and they did

218
00:10:44,619 --> 00:10:41,179
so with the very large telescope and

219
00:10:47,980 --> 00:10:44,629
they got this observation of it and you

220
00:10:51,009 --> 00:10:47,990
pick it out no so let's give you the

221
00:10:54,850 --> 00:10:51,019
arrow all right right there

222
00:10:56,289 --> 00:10:54,860
okay that is an observation and people

223
00:10:58,210 --> 00:10:56,299
were measuring it with various

224
00:11:00,369 --> 00:10:58,220
telescopes around the world and

225
00:11:02,259 --> 00:11:00,379
basically trying to get all the

226
00:11:04,569 --> 00:11:02,269
characteristics of it and one of the

227
00:11:07,269 --> 00:11:04,579
most intriguing characteristics of it is

228
00:11:08,080 --> 00:11:07,279
that its brightness change so this is

229
00:11:10,630 --> 00:11:08,090
the magnitude

230
00:11:13,210 --> 00:11:10,640
the brightness and you can see that it's

231
00:11:17,380 --> 00:11:13,220
going up and down and up and down by a

232
00:11:22,900 --> 00:11:17,390
large amount okay a very large variation

233
00:11:24,400 --> 00:11:22,910
in the brightness and so the one paper

234
00:11:25,900 --> 00:11:24,410
which got a lot of press from the

235
00:11:28,020 --> 00:11:25,910
European Southern Observatory because

236
00:11:30,250 --> 00:11:28,030
they put out a press release about it

237
00:11:33,490 --> 00:11:30,260
determined that it was about it was

238
00:11:36,850 --> 00:11:33,500

small about 400 meters and had a very

239
00:11:39,490 --> 00:11:36,860
long elongated aspect ratio to explain

240
00:11:44,350 --> 00:11:39,500
this light curve they deduced that it

241
00:11:46,510 --> 00:11:44,360
was an aspect ratio of 10 to 1 about 400

242
00:11:49,930 --> 00:11:46,520
meters long and only about 1/10 that

243
00:11:52,090 --> 00:11:49,940
width when they did that they put out an

244
00:11:53,350 --> 00:11:52,100
artist's illustration of it so this is

245
00:11:56,440 --> 00:11:53,360
what you may have seen floating around

246
00:11:58,180 --> 00:11:56,450
the internet this image of here is the

247
00:12:00,870 --> 00:11:58,190
picture of our interstellar our first

248
00:12:05,100 --> 00:12:00,880
inner cell or visitor and has this

249
00:12:06,790 --> 00:12:05,110
unbelievably long thin profile all right

250
00:12:09,850 --> 00:12:06,800
that's crazy

251
00:12:12,670 --> 00:12:09,860
that's just plain weird we don't get

252
00:12:14,860 --> 00:12:12,680
things with a 10 to 1 profile we've

253
00:12:17,470 --> 00:12:14,870
never seen two antennae one aspect ratio

254
00:12:18,670 --> 00:12:17,480
in our solar system this is just sort of

255
00:12:21,190 --> 00:12:18,680
mind-blowing ok

256
00:12:23,080 --> 00:12:21,200
and of course everyone said hey you know

257
00:12:26,560 --> 00:12:23,090
what this looks like this looks like a

258
00:12:28,060 --> 00:12:26,570
spaceship ok and it matches what the

259
00:12:31,270 --> 00:12:28,070
reason why I call this rendezvous with

260
00:12:33,670 --> 00:12:31,280
drama is because it matches the opening

261
00:12:35,830 --> 00:12:33,680
of arthur c clarke spoke rendezvous with

262
00:12:37,990 --> 00:12:35,840
Rama where there an alien spaceship

263
00:12:40,210 --> 00:12:38,000

flies through our solar system etc and

264
00:12:42,070 --> 00:12:40,220
so we were all excited about oh my gosh

265
00:12:48,780 --> 00:12:42,080
it's got all these crazy characteristics

266
00:12:51,220 --> 00:12:48,790
it must be aliens yes it's not aliens ok

267
00:12:53,740 --> 00:12:51,230
the internet loves this they love to

268
00:12:56,650 --> 00:12:53,750
jump the gun and they definitely jump

269
00:12:57,910 --> 00:12:56,660
the gun here so I thought I would just

270
00:13:03,700 --> 00:12:57,920
give you a little bit of a summary of

271
00:13:08,080 --> 00:13:03,710
what we do know about Oh mwah mwah

272
00:13:12,250 --> 00:13:08,090
okay that is a I believe it's a Hawaiian

273
00:13:15,280 --> 00:13:12,260
name of something about a visitor I

274
00:13:16,930 --> 00:13:15,290
can't remember what it means but I just

275
00:13:18,850 --> 00:13:16,940
try to remember Oh mwah

276
00:13:20,800 --> 00:13:18,860
okay trying to get that pronunciation

277
00:13:21,879 --> 00:13:20,810
was difficult first of all the orbit is

278
00:13:24,369 --> 00:13:21,889
consistent with an

279
00:13:26,879 --> 00:13:24,379
interstellar origin do we know that it

280
00:13:29,739 --> 00:13:26,889
truly is interstellar in origin have

281
00:13:31,150 --> 00:13:29,749
none we can't prove that it's

282
00:13:34,210 --> 00:13:31,160
interstellar in origin but the orbit is

283
00:13:36,699 --> 00:13:34,220
consistent okay you can't argue about

284
00:13:39,669 --> 00:13:36,709
lacor 'but you know says that you know

285
00:13:41,619 --> 00:13:39,679
it could have definitely a plausible

286
00:13:45,699 --> 00:13:41,629
origin is from interstellar space okay

287
00:13:47,409 --> 00:13:45,709
it rotates every set 37.3 hours so it's

288
00:13:50,409 --> 00:13:47,419

got event very quick it can't be too

289
00:13:52,030 --> 00:13:50,419
large okay it's got a relatively quick

290
00:13:53,859 --> 00:13:52,040
rotation and there are these large

291
00:13:55,960 --> 00:13:53,869
brightness variations okay

292
00:13:57,429 --> 00:13:55,970
those are the three things I in looking

293
00:14:01,900 --> 00:13:57,439
at the literature that we can say for

294
00:14:06,129 --> 00:14:01,910
sure now what's more is what we don't

295
00:14:07,900 --> 00:14:06,139
know about Oh mwah mwah it's sighs the

296
00:14:10,059 --> 00:14:07,910
estimate that was published in the ESO

297
00:14:13,179 --> 00:14:10,069
press release was about 400 meters long

298
00:14:14,259 --> 00:14:13,189
okay but that was just an estimate and

299
00:14:17,079 --> 00:14:14,269
there are other groups that are getting

300
00:14:19,419 --> 00:14:17,089
other sizes it's bat very well resolved

301
00:14:21,579 --> 00:14:19,429
so it's very hard to estimate the size

302
00:14:24,009 --> 00:14:21,589
you actually have to assume other

303
00:14:26,669 --> 00:14:24,019
parameters about the object in order to

304
00:14:29,289 --> 00:14:26,679
estimate that size the axis ratio

305
00:14:31,900 --> 00:14:29,299
although the highly publicized one was

306
00:14:33,429 --> 00:14:31,910
this 10 to one asked axis ratio there

307
00:14:36,159 --> 00:14:33,439
are other papers that are down to a

308
00:14:38,439 --> 00:14:36,169
three to one aspect ratio okay so the

309
00:14:40,869 --> 00:14:38,449
researchers don't agree on what the

310
00:14:44,259 --> 00:14:40,879
access ratio is the color of the object

311
00:14:46,090 --> 00:14:44,269
or and most importantly its albedo its

312
00:14:49,090 --> 00:14:46,100
brightness how much less sunlight it

313
00:14:50,559 --> 00:14:49,100

reflects back and the variations that

314
00:14:52,749 --> 00:14:50,569
could be on the surface we don't know

315
00:14:55,239 --> 00:14:52,759
about that a lot of that brightness

316
00:14:58,059 --> 00:14:55,249
change could be explained by albedo

317
00:15:00,069 --> 00:14:58,069
variations for example we have the moon

318
00:15:02,199 --> 00:15:00,079
in the solar system i habitus which is

319
00:15:04,929 --> 00:15:02,209
really dark on one side and really

320
00:15:06,460 --> 00:15:04,939
bright on another and that alone can

321
00:15:09,009 --> 00:15:06,470
produce very strong brightness

322
00:15:11,619 --> 00:15:09,019
variations as if you were watching

323
00:15:12,909 --> 00:15:11,629
Iapetus rotate you would get very long

324
00:15:14,739 --> 00:15:12,919
brightness strong about your

325
00:15:17,109 --> 00:15:14,749
segregations furthermore the

326
00:15:19,900 --> 00:15:17,119
measurements of the color was between

327
00:15:20,769 --> 00:15:19,910
two different groups are inconsistent

328
00:15:22,689 --> 00:15:20,779
with each other

329
00:15:24,400 --> 00:15:22,699
this one haired there in certainties

330
00:15:26,289 --> 00:15:24,410
that here this one's in certainties here

331
00:15:29,529 --> 00:15:26,299
and they say they disagree at the three

332
00:15:31,269 --> 00:15:29,539
sigma level so we just we don't know the

333
00:15:33,460 --> 00:15:31,279
color we certainly don't know its

334
00:15:34,889 --> 00:15:33,470
composition yet although if it's going

335
00:15:37,799 --> 00:15:34,899
to rotate in this path it

336
00:15:40,499 --> 00:15:37,809
this type of speed it should be rocky or

337
00:15:42,329 --> 00:15:40,509
metallic or something should be hard and

338
00:15:45,660 --> 00:15:42,339

the most important thing we don't know

339
00:15:47,970 --> 00:15:45,670
is the group characteristics this is a

340
00:15:50,489 --> 00:15:47,980
group of one if this is the first

341
00:15:52,590 --> 00:15:50,499
interstellar object to come through the

342
00:15:54,989 --> 00:15:52,600
solar system that we have observed we

343
00:15:58,350 --> 00:15:54,999
don't know what we should expect for

344
00:16:01,079 --> 00:15:58,360
these so part of the interpretation of

345
00:16:03,749 --> 00:16:01,089
observations is sort of knowing what

346
00:16:06,679 --> 00:16:03,759
type of object you're looking at so

347
00:16:12,019 --> 00:16:06,689
we're going to need more observations

348
00:16:14,489 --> 00:16:12,029
now that's the cool thing the pan-starrs

349
00:16:16,679 --> 00:16:14,499
project was able to trigger this and

350
00:16:19,109 --> 00:16:16,689
I'll let everyone know about it and

351
00:16:21,929 --> 00:16:19,119
allow to observe it we had the large

352
00:16:24,419 --> 00:16:21,939
synoptic survey telescope LSST that will

353
00:16:26,730 --> 00:16:24,429
be online next decade which will be a

354
00:16:29,400 --> 00:16:26,740
boon for this field because it will be

355
00:16:34,049 --> 00:16:29,410
taking pictures of the whole sky every

356
00:16:38,210 --> 00:16:34,059
night so this type of observation will

357
00:16:40,590 --> 00:16:38,220
be really prevalent in the next decade I

358
00:16:42,210 --> 00:16:40,600
not gonna say that I have answers for

359
00:16:43,499 --> 00:16:42,220
you tonight I'm not gonna say I have

360
00:16:45,720 --> 00:16:43,509
answers for you tomorrow

361
00:16:48,720 --> 00:16:45,730
but in the net counting decades we will

362
00:16:51,449 --> 00:16:48,730
have lots of observations we expect to

363
00:16:54,150 --> 00:16:51,459

have these kind of observations now of

364
00:16:55,530 --> 00:16:54,160
course we're the home of Hubble here so

365
00:16:59,189 --> 00:16:55,540
half of you in the audience are going

366
00:17:03,929 --> 00:16:59,199
okay so what did Hubble see well Hubble

367
00:17:08,370 --> 00:17:03,939
has observed this object and that's all

368
00:17:12,329 --> 00:17:08,380
I'm allowed to say we have not gotten

369
00:17:14,610 --> 00:17:12,339
any results that we are that the hope

370
00:17:17,549 --> 00:17:14,620
that we were going to take out for press

371
00:17:20,100 --> 00:17:17,559
so unfortunately I have to leave you

372
00:17:22,380 --> 00:17:20,110
with a final slide that says to be

373
00:17:23,970 --> 00:17:22,390
continued okay all right there will be

374
00:17:25,649 --> 00:17:23,980
more about this object people are

375
00:17:27,559 --> 00:17:25,659
studying it's goingit's leaving the

376
00:17:31,560 --> 00:17:27,569
solar system at a relatively rapid rate

377
00:17:33,419 --> 00:17:31,570
so people are studying it in detail in

378
00:17:34,440 --> 00:17:33,429
the next couple months all of the

379
00:17:36,870 --> 00:17:34,450
observations that we're ever going to

380
00:17:37,889 --> 00:17:36,880
get of this object will be done and

381
00:17:39,960 --> 00:17:37,899
we'll see where that where they lead

382
00:17:42,080 --> 00:17:39,970
okay all right

383
00:17:45,480 --> 00:17:42,090
so that's our news from the universe and

384
00:17:49,070 --> 00:17:45,490
now we go to our featured speaker

385
00:17:53,820 --> 00:17:49,080
tonight and let me get to

386
00:17:55,680 --> 00:17:53,830
her lips you're gonna have to log in

387
00:17:57,750 --> 00:17:55,690
your machine went up all right so our

388
00:18:01,230 --> 00:17:57,760

featured speaker tonight is Kelsey

389
00:18:04,350 --> 00:18:01,240
glazier from Towson University and she

390
00:18:07,620 --> 00:18:04,360
is for the my hosting period the very

391
00:18:16,950 --> 00:18:07,630
first undergraduate we've ever had speak

392
00:18:19,650 --> 00:18:16,960
at the public lecture series okay she is

393
00:18:22,110 --> 00:18:19,660
on the James urn over the earnest II

394
00:18:24,180 --> 00:18:22,120
wouldn't scholarship at Towson

395
00:18:25,700 --> 00:18:24,190
University for this year and over the

396
00:18:28,530 --> 00:18:25,710
past summer she was doing research

397
00:18:30,090 --> 00:18:28,540
supported by the Maryland space grant

398
00:18:31,440 --> 00:18:30,100
observatory the group across the street

399
00:18:33,660 --> 00:18:31,450
that runs the observer ends the

400
00:18:38,100 --> 00:18:33,670
telescope she was supported by them

401
00:18:40,740 --> 00:18:38,110
working on Olbers paradox and the light

402
00:18:43,280 --> 00:18:40,750
deflection during the 2017 solar eclipse

403
00:18:45,419 --> 00:18:43,290
and let me try this again

404
00:18:54,600 --> 00:18:45,429
there we go number one now it should

405
00:18:56,760 --> 00:18:54,610
connect you there we go okay and her

406
00:18:59,340 --> 00:18:56,770
professor who's she's working with has

407
00:19:01,799 --> 00:18:59,350
already put on her webpage that she's

408
00:19:03,600 --> 00:19:01,809
giving a public outreach lecture at the

409
00:19:09,270 --> 00:19:03,610
Hubble Space Science Telescope Institute

410
00:19:10,980 --> 00:19:09,280
he's got to get that right so it's

411
00:19:11,910 --> 00:19:10,990
already up there about it all right so

412
00:19:18,100 --> 00:19:11,920
ladies and gentlemen

413
00:19:26,500 --> 00:19:25,419

oh um as dr. Sommer said my name's

414
00:19:29,100 --> 00:19:26,510
Kelsey Glaser

415
00:19:31,720 --> 00:19:29,110
I'm undergraduate at Towson University

416
00:19:34,390 --> 00:19:31,730
my major is in physics with a

417
00:19:36,310 --> 00:19:34,400
concentration in astrophysics and again

418
00:19:38,410 --> 00:19:36,320
this summer I was allowed the

419
00:19:41,230 --> 00:19:38,420
opportunity to specifically dive into

420
00:19:43,210 --> 00:19:41,240
these titude subjects and you'll hear

421
00:19:44,980 --> 00:19:43,220
about my research as well but we'll also

422
00:19:48,310 --> 00:19:44,990
cover in this talk some of the theory

423
00:19:49,990 --> 00:19:48,320
behind it as well so just to get you

424
00:19:52,150 --> 00:19:50,000
familiar with some of the people who

425
00:19:54,760 --> 00:19:52,160
were actually working with me on this

426
00:19:56,860 --> 00:19:54,770
you'll see myself and dr. James over

427
00:20:00,640 --> 00:19:56,870
doing my mentor in front of the Towson

428
00:20:03,220 --> 00:20:00,650
University 16 inch telescope for any of

429
00:20:06,100 --> 00:20:03,230
you telescope enthusiasts it's actually

430
00:20:09,010 --> 00:20:06,110
a Richie 14 reflector with an equatorial

431
00:20:12,190 --> 00:20:09,020
mount and in the far image you'll see

432
00:20:15,549 --> 00:20:12,200
myself and dr. Alexander stars atop the

433
00:20:17,289 --> 00:20:15,559
16 inch but you'll also see mr. Chris

434
00:20:19,150 --> 00:20:17,299
misko it's in his telescope that we

435
00:20:20,860 --> 00:20:19,160
actually were able to take down with us

436
00:20:24,370 --> 00:20:20,870
to South Carolina for when we actually

437
00:20:26,530 --> 00:20:24,380
went to view the solar eclipse and you

438
00:20:28,960 --> 00:20:26,540

also see two young ladies Kari

439
00:20:30,880 --> 00:20:28,970
McClelland and Charlotte Edwards these

440
00:20:33,220 --> 00:20:30,890
two ladies were high school interns who

441
00:20:36,130 --> 00:20:33,230
actually came along for the ride so it

442
00:20:39,760 --> 00:20:36,140
was a quite a nice quite a nice group I

443
00:20:43,169 --> 00:20:39,770
would say um so jumping into overs

444
00:20:45,730 --> 00:20:43,179
paradox why is the night sky dark right

445
00:20:48,850 --> 00:20:45,740
we all agreed that the universe is

446
00:20:51,730 --> 00:20:48,860
static and infinite and that light is

447
00:20:54,430 --> 00:20:51,740
evenly distributed through it so

448
00:20:56,830 --> 00:20:54,440
technically by that definition no matter

449
00:20:59,049 --> 00:20:56,840
where I look in the sky I should always

450
00:21:02,530 --> 00:20:59,059
see some sort of light a star or a

451
00:21:05,110 --> 00:21:02,540
galaxy but I don't write the night sky

452
00:21:08,710 --> 00:21:05,120
is dark it's actually more dark than it

453
00:21:12,130 --> 00:21:08,720
is light that's why it's nice and you

454
00:21:14,140 --> 00:21:12,140
know why is that if you're having a hard

455
00:21:16,990 --> 00:21:14,150
time understanding what this is like

456
00:21:18,789 --> 00:21:17,000
imagine yourself in a forest and you're

457
00:21:20,830 --> 00:21:18,799
standing in the middle of it and no

458
00:21:23,680 --> 00:21:20,840
matter where you look your eye would

459
00:21:25,350 --> 00:21:23,690
always hit a tree the same thing applies

460
00:21:28,210 --> 00:21:25,360
no matter where we look in the sky

461
00:21:30,700 --> 00:21:28,220
technically we should always be seeing a

462
00:21:33,760 --> 00:21:30,710
quick galaxy or a star

463
00:21:35,889 --> 00:21:33,770

and it turns out when we take our most

464
00:21:38,380 --> 00:21:35,899
powerful telescope pointed out one of

465
00:21:41,350 --> 00:21:38,390
the darkest parts of our night sky for

466
00:21:44,769 --> 00:21:41,360
ten whole days we still come up with

467
00:21:47,230 --> 00:21:44,779
darkness in between these galaxies why

468
00:21:49,360 --> 00:21:47,240
though and just a quick background on

469
00:21:52,299 --> 00:21:49,370
the this image it's called the Hubble

470
00:21:55,450 --> 00:21:52,309
Deep Field and they actually went back

471
00:21:59,980 --> 00:21:55,460
the Hubble Deep Field is inside Ursa

472
00:22:02,110 --> 00:21:59,990
Major and later on and I believe 2004

473
00:22:03,580 --> 00:22:02,120
they went back and took some more images

474
00:22:06,159 --> 00:22:03,590
of another part of sky and they called

475
00:22:06,909 --> 00:22:06,169
it the Hubble Ultra Deep Field inside of

476
00:22:10,750 --> 00:22:06,919
Fornax

477
00:22:12,909 --> 00:22:10,760
and they took one in infrared as well

478
00:22:13,990 --> 00:22:12,919
and then compiled it into the picture

479
00:22:16,299 --> 00:22:14,000
you're holding in your hands right now

480
00:22:22,419 --> 00:22:16,309
the extreme deep field

481
00:22:23,919 --> 00:22:22,429
dun-dun-dun and it's actually as a quick

482
00:22:29,080 --> 00:22:23,929
side note not to run off on a tangent

483
00:22:32,590 --> 00:22:29,090
but inside the extreme deep field they

484
00:22:35,139 --> 00:22:32,600
apparently spotted a galaxy that's about

485
00:22:37,480 --> 00:22:35,149
thirteen point two billion light-years

486
00:22:40,000 --> 00:22:37,490
away now this is a significant find

487
00:22:42,430 --> 00:22:40,010
because that means this galaxy is lying

488
00:22:45,940 --> 00:22:42,440

at the very edges of our observable

489
00:22:46,899 --> 00:22:45,950
universe and it's age is significant

490
00:22:48,779 --> 00:22:46,909
right

491
00:22:51,010 --> 00:22:48,789
the universe has only existed for about

492
00:22:53,649 --> 00:22:51,020
fourteen billion years and this thing is

493
00:22:56,440 --> 00:22:53,659
almost the age of our universe think

494
00:22:58,330 --> 00:22:56,450
about let's say you had a baby you went

495
00:22:59,850 --> 00:22:58,340
to bed and then then wake up the next

496
00:23:02,200 --> 00:22:59,860
morning and the baby is now an adult

497
00:23:05,230 --> 00:23:02,210
that's kind of like what astronomers saw

498
00:23:07,899 --> 00:23:05,240
right this the the significance behind

499
00:23:12,370 --> 00:23:07,909
this is that you know galaxies take time

500
00:23:14,500 --> 00:23:12,380
to form and this one is showing that it

501
00:23:16,299 --> 00:23:14,510
formed rather quickly so either you know

502
00:23:18,700 --> 00:23:16,309
there's something very special about

503
00:23:21,549 --> 00:23:18,710
that baby or there's something we're not

504
00:23:24,399 --> 00:23:21,559
understanding about the way you know

505
00:23:26,680 --> 00:23:24,409
humans develop and grow so there so the

506
00:23:30,159 --> 00:23:26,690
existence of this galaxy that's thirteen

507
00:23:32,590 --> 00:23:30,169
point two billion light years away makes

508
00:23:34,960 --> 00:23:32,600
us wonder about you know is this just a

509
00:23:36,430 --> 00:23:34,970
special galaxy is this an anomaly or you

510
00:23:37,899 --> 00:23:36,440
know is this a mistake or you know is

511
00:23:39,879 --> 00:23:37,909
there some crucial piece of evidence

512
00:23:43,880 --> 00:23:39,889
we're not understanding it about galaxy

513
00:23:47,299 --> 00:23:43,890

formation it's actually pretty neat

514
00:23:49,160 --> 00:23:47,309
it's a pretty neat subject so back to

515
00:23:51,740 --> 00:23:49,170
what I was discussing before you know

516
00:23:55,370 --> 00:23:51,750
the dark night sky was pondered by many

517
00:23:56,750 --> 00:23:55,380
philosophers astronomers physicists and

518
00:23:59,419 --> 00:23:56,760
I'm going to talk about a few of their

519
00:24:01,310 --> 00:23:59,429
theories they proposed and the title

520
00:24:03,590 --> 00:24:01,320
already gives it away many incomplete

521
00:24:05,750 --> 00:24:03,600
answers you'll see some and we're gonna

522
00:24:09,260 --> 00:24:05,760
go over the ones that are really cool

523
00:24:12,350 --> 00:24:09,270
but not exactly the right ones

524
00:24:14,630 --> 00:24:12,360
we'll start with Kepler he believed in

525
00:24:17,180 --> 00:24:14,640
an island universe right there's he

526
00:24:19,159 --> 00:24:17,190
believed there's the Sun there's us and

527
00:24:22,220 --> 00:24:19,169
there's these glowing things in the sky

528
00:24:25,850 --> 00:24:22,230
around the Sun and that's it and he and

529
00:24:28,250 --> 00:24:25,860
the thing is right in his universe he

530
00:24:30,740 --> 00:24:28,260
has a finite amount of stars and only

531
00:24:32,840 --> 00:24:30,750
like a finite amount of space they can

532
00:24:34,640 --> 00:24:32,850
exist however that's not the universe we

533
00:24:36,320 --> 00:24:34,650
live in we live in an infinite universe

534
00:24:39,860 --> 00:24:36,330
and the light is evenly distributed

535
00:24:41,930 --> 00:24:39,870
through it so Kepler is kind of outdated

536
00:24:45,860 --> 00:24:41,940
and he got the boot is there he got the

537
00:24:48,260 --> 00:24:45,870
boot going further we have people like

538
00:24:50,510 --> 00:24:48,270

dishes or and overs himself who thought

539
00:24:52,700 --> 00:24:50,520
you know maybe what's happening is that

540
00:24:54,680 --> 00:24:52,710
this light is just getting blocked by

541
00:24:57,799 --> 00:24:54,690
stuff like intergalactic medium like

542
00:24:59,870 --> 00:24:57,809
dust right but it's important to note

543
00:25:03,470 --> 00:24:59,880
that this does happen this is happening

544
00:25:06,680 --> 00:25:03,480
in in the universe but it can't solely

545
00:25:09,799 --> 00:25:06,690
be the only answer to the paradox for

546
00:25:11,750 --> 00:25:09,809
for two reasons one if there was one

547
00:25:13,820 --> 00:25:11,760
there can't be that much dust in the

548
00:25:17,090 --> 00:25:13,830
universe there can and even if there was

549
00:25:18,289 --> 00:25:17,100
two if there was that dust concealing

550
00:25:21,650 --> 00:25:18,299
all that light would start to heat up

551
00:25:25,640 --> 00:25:21,660
and it then would radiate so we would

552
00:25:28,370 --> 00:25:25,650
see that light as well so it's important

553
00:25:30,470 --> 00:25:28,380
to remember absorption is happening but

554
00:25:32,060 --> 00:25:30,480
isn't it does not account for the entire

555
00:25:35,230 --> 00:25:32,070
reason why we see darkness in the night

556
00:25:42,680 --> 00:25:40,820
Immanuel Kant is a philosopher in 1755

557
00:25:45,039 --> 00:25:42,690
he came out with the idea of the fractal

558
00:25:48,590 --> 00:25:45,049
universe this is a really cool theory

559
00:25:50,630 --> 00:25:48,600
it's simply put there that if you take

560
00:25:52,010 --> 00:25:50,640
the same pattern in this case a cross

561
00:25:54,590 --> 00:25:52,020
but you can choose any pattern you like

562
00:25:57,100 --> 00:25:54,600
and if you just repeat it over and over

563
00:25:59,950 --> 00:25:57,110

and over making a scale large enlargen

564
00:26:03,460 --> 00:25:59,960
as it is in the image right here you can

565
00:26:07,630 --> 00:26:03,470
see where certain lines of sight you

566
00:26:10,450 --> 00:26:07,640
would get darkness however Kant's a

567
00:26:12,820 --> 00:26:10,460
proposal theory only works for

568
00:26:15,100 --> 00:26:12,830
small-scale and universes right if we

569
00:26:19,090 --> 00:26:15,110
were to apply you know this fractal this

570
00:26:20,830 --> 00:26:19,100
pattern to infinity weird end up at the

571
00:26:22,450 --> 00:26:20,840
same problem we started at we would

572
00:26:24,730 --> 00:26:22,460
technically then have to see light

573
00:26:27,090 --> 00:26:24,740
everywhere we looked which is not the

574
00:26:31,840 --> 00:26:27,100
case therefore a fractal universe is out

575
00:26:34,390 --> 00:26:31,850
so Zoeller came next he thought you know

576
00:26:37,570 --> 00:26:34,400
space was positively curved making this

577
00:26:39,909 --> 00:26:37,580
sphere which would cause the universe to

578
00:26:41,799 --> 00:26:39,919
be unbounded and infinite but it would

579
00:26:44,950 --> 00:26:41,809
make all the light inside of it finite

580
00:26:46,840 --> 00:26:44,960
and going off this model here what it

581
00:26:49,900 --> 00:26:46,850
would mean is that like I would see a

582
00:26:52,840 --> 00:26:49,910
star over here coming towards me but it

583
00:26:54,100 --> 00:26:52,850
would also travel all the way around the

584
00:26:55,690 --> 00:26:54,110
sphere and I could see it at the

585
00:26:57,490 --> 00:26:55,700
opposite direction it would be light

586
00:27:01,810 --> 00:26:57,500
from the same star but just at the

587
00:27:03,340 --> 00:27:01,820
opposite direction and you know if we

588
00:27:04,840 --> 00:27:03,350

only have a finite amount of stars doing

589
00:27:07,000 --> 00:27:04,850
this there's gotta be lines of sight

590
00:27:09,250 --> 00:27:07,010
that we don't see anything

591
00:27:11,590 --> 00:27:09,260
however this this theory falls through

592
00:27:13,840 --> 00:27:11,600
because of gravitational lensing which

593
00:27:17,580 --> 00:27:13,850
is a topic we'll talk about later but

594
00:27:19,930 --> 00:27:17,590
basically not to spoil anything but the

595
00:27:22,620 --> 00:27:19,940
what would happen is you know these

596
00:27:25,780 --> 00:27:22,630
these photons traveling through space

597
00:27:28,030 --> 00:27:25,790
would pass by massive objects these

598
00:27:30,520 --> 00:27:28,040
massive objects due to the warping it

599
00:27:32,590 --> 00:27:30,530
does to space-time would cause it to

600
00:27:35,169 --> 00:27:32,600
deflect it would be focus that light and

601
00:27:36,850 --> 00:27:35,179
therefore instead of meeting up back

602
00:27:39,280 --> 00:27:36,860
where it started

603
00:27:43,120 --> 00:27:39,290
it would go off right in every direction

604
00:27:46,330 --> 00:27:43,130
and then by that nature we would then

605
00:27:49,240 --> 00:27:46,340
see light in every direction and then we

606
00:27:51,760 --> 00:27:49,250
end up back at the problem so curved

607
00:27:54,370 --> 00:27:51,770
space goodbye

608
00:27:56,500 --> 00:27:54,380
the last incomplete answer I'm going to

609
00:28:01,390 --> 00:27:56,510
talk about is cosmic expansion and

610
00:28:02,890 --> 00:28:01,400
cosmic expansion like absorption is part

611
00:28:05,950 --> 00:28:02,900
is partly what's happening in the

612
00:28:08,260 --> 00:28:05,960
universe but again it can't solely stand

613
00:28:09,100 --> 00:28:08,270

on its own as being the only solution to

614
00:28:10,520 --> 00:28:09,110
the paradox

615
00:28:12,080 --> 00:28:10,530
so what cosmic

616
00:28:15,530 --> 00:28:12,090
expansion is saying and it was proposed

617
00:28:17,990 --> 00:28:15,540
by steady state theorists that um the

618
00:28:19,730 --> 00:28:18,000
universe is expanding as a steady-state

619
00:28:22,280 --> 00:28:19,740
uniformly everything inside of it is U

620
00:28:24,950 --> 00:28:22,290
is expanding together right and

621
00:28:27,230 --> 00:28:24,960
therefore it's by an expanding universe

622
00:28:30,590 --> 00:28:27,240
it's doing two things to my photon it's

623
00:28:32,870 --> 00:28:30,600
in its elongated its wavelengths and

624
00:28:35,300 --> 00:28:32,880
it's also increasing the distance and

625
00:28:37,520 --> 00:28:35,310
needs to travel for us to for it to

626
00:28:40,190 --> 00:28:37,530
reach us right so it makes sense that

627
00:28:42,170 --> 00:28:40,200
you know the more expansion the less

628
00:28:44,720 --> 00:28:42,180
brightness I'm going to see because that

629
00:28:47,240 --> 00:28:44,730
means more distance and these photons

630
00:28:49,340 --> 00:28:47,250
have to travel to get to me but in order

631
00:28:50,960 --> 00:28:49,350
for study state there's cosmic expansion

632
00:28:53,060 --> 00:28:50,970
to work that would mean that the

633
00:28:56,780 --> 00:28:53,070
universe would have to expand uniformly

634
00:28:58,970 --> 00:28:56,790
and once the once cosmic microwave

635
00:29:01,370 --> 00:28:58,980
background came around a lot of people

636
00:29:03,380 --> 00:29:01,380
ended up abandoning this idea because

637
00:29:07,760 --> 00:29:03,390
what the Cosmic Microwave Background did

638
00:29:11,180 --> 00:29:07,770

was it showed a lot of inflation models

639
00:29:13,640 --> 00:29:11,190
came out as an outcome of finding the

640
00:29:15,080 --> 00:29:13,650
Cosmic Microwave Background and for

641
00:29:17,900 --> 00:29:15,090
those of you who aren't familiar with

642
00:29:21,110 --> 00:29:17,910
inflation it is what we believe to be a

643
00:29:24,400 --> 00:29:21,120
point in time right um after the Big

644
00:29:27,650 --> 00:29:24,410
Bang where the universe actually

645
00:29:31,280 --> 00:29:27,660
expanded faster than possibly the speed

646
00:29:32,780 --> 00:29:31,290
of light now if you're like wait nothing

647
00:29:34,360 --> 00:29:32,790
can move faster than the speed of light

648
00:29:40,460 --> 00:29:34,370
you don't know what you're talking about

649
00:29:42,050 --> 00:29:40,470
true no I'm kidding everybody but you

650
00:29:44,150 --> 00:29:42,060
know everything inside the universe is

651
00:29:48,290 --> 00:29:44,160
bound to this law that nothing can

652
00:29:51,280 --> 00:29:48,300
exceed the speed of light but the

653
00:29:54,560 --> 00:29:51,290
universe itself isn't bound to this law

654
00:29:56,090 --> 00:29:54,570
therefore there's no technically rule

655
00:29:58,580 --> 00:29:56,100
say there's no technical there's

656
00:30:00,800 --> 00:29:58,590
technically no rule saying that the

657
00:30:02,720 --> 00:30:00,810
universe can't expand faster than speed

658
00:30:07,220 --> 00:30:02,730
of life so when CMB came around and gave

659
00:30:09,770 --> 00:30:07,230
race two models of inflation cosmic

660
00:30:13,690 --> 00:30:09,780
expansion being the sole reason why you

661
00:30:15,800 --> 00:30:13,700
know the night sky is dark got the boot

662
00:30:17,450 --> 00:30:15,810
and of course there's many other

663
00:30:19,610 --> 00:30:17,460

theories these are just listing a few

664
00:30:20,840 --> 00:30:19,620
cool ones that intrigued me this one

665
00:30:22,850 --> 00:30:20,850
tired light I really wish I could talk

666
00:30:23,690 --> 00:30:22,860
about it's literally the idea that light

667
00:30:31,399 --> 00:30:23,700
just gets

668
00:30:33,019 --> 00:30:31,409
hired on its way to us you know yeah but

669
00:30:35,960 --> 00:30:33,029
there's a lot more out there and if

670
00:30:38,360 --> 00:30:35,970
you're interested you know there's a ton

671
00:30:40,220 --> 00:30:38,370
more of theories of why the night sky is

672
00:30:42,740 --> 00:30:40,230
dark but to fast forward a little bit

673
00:30:45,519 --> 00:30:42,750
we're gonna actually look at the guy who

674
00:30:51,200 --> 00:30:45,529
figured it out

675
00:30:53,649 --> 00:30:51,210
recognized him can you believe it a poet

676
00:30:57,529 --> 00:30:53,659
beat it beat us to the answer

677
00:30:59,889 --> 00:30:57,539
ding now there is some controversy over

678
00:31:04,639 --> 00:30:59,899
who actually came up with the solution

679
00:31:07,730 --> 00:31:04,649
in Edgar Allen Poe Edgar Allen Poe's

680
00:31:09,409 --> 00:31:07,740
poem Eureka a prose poem Eureka he

681
00:31:12,769 --> 00:31:09,419
actually touched the subject here as you

682
00:31:18,070 --> 00:31:12,779
can see of why exactly the night sky is

683
00:31:20,570 --> 00:31:18,080
dark but later 10 years later in 1850 58

684
00:31:22,370 --> 00:31:20,580
Johann mad ler came out with an actual

685
00:31:24,350 --> 00:31:22,380
paper saying this is why the night skies

686
00:31:27,350 --> 00:31:24,360
are right so there's some discrepancy on

687
00:31:29,570 --> 00:31:27,360
who they believe you know was potent at

688
00:31:31,850 --> 00:31:29,580

it or was he really you know saying

689
00:31:34,960 --> 00:31:31,860
something he's a poet do we want to

690
00:31:37,070 --> 00:31:34,970
trust a poet / a scientist you know it's

691
00:31:38,240 --> 00:31:37,080
it's not a here no there so I'll leave

692
00:31:40,159 --> 00:31:38,250
it to you to decide who you think

693
00:31:42,169 --> 00:31:40,169
thought of it first but I do want to

694
00:31:43,879 --> 00:31:42,179
read you this section of his poem

695
00:31:46,639 --> 00:31:43,889
because it's it's a quite a profound

696
00:31:49,039 --> 00:31:46,649
statement he says where the succession

697
00:31:51,620 --> 00:31:49,049
of stars endless then the background of

698
00:31:53,899 --> 00:31:51,630
the sky would present us an uniform

699
00:31:56,720 --> 00:31:53,909
luminosity like that displayed by the

700
00:31:59,389 --> 00:31:56,730
galaxy since there could be absolutely

701
00:32:02,210 --> 00:31:59,399
no point in all that background at which

702
00:32:04,009 --> 00:32:02,220
would not exist a star the only mode

703
00:32:06,200 --> 00:32:04,019
therefore in which under such a state of

704
00:32:08,659 --> 00:32:06,210
affairs we could comprehend the voids

705
00:32:11,690 --> 00:32:08,669
which our telescopes find in innumerable

706
00:32:13,970 --> 00:32:11,700
directions would be by supposing the

707
00:32:16,460 --> 00:32:13,980
distance of the invisible background so

708
00:32:19,940 --> 00:32:16,470
immense that no ray from it has yet been

709
00:32:23,210 --> 00:32:19,950
able to reach us at all that this may be

710
00:32:25,070 --> 00:32:23,220
so you shall venture to deny I maintain

711
00:32:27,879 --> 00:32:25,080
simply that we have not even the shadow

712
00:32:31,370 --> 00:32:27,889
of a reason for believing that it is so

713
00:32:33,049 --> 00:32:31,380

so I actually highlighted you know all

714
00:32:35,090 --> 00:32:33,059
the theatrics but I actually highlighted

715
00:32:36,940 --> 00:32:35,100
the most important part and if you're

716
00:32:38,440 --> 00:32:36,950
still having trouble like

717
00:32:41,410 --> 00:32:38,450
kind of digging it out because poets

718
00:32:44,770 --> 00:32:41,420
like to be all you know ambiguous about

719
00:32:48,520 --> 00:32:44,780
stuff he's basically proposing that you

720
00:32:49,900 --> 00:32:48,530
know light has a finite speed and it's

721
00:32:52,930 --> 00:32:49,910
only been allowed a certain amount of

722
00:32:54,669 --> 00:32:52,940
time to travel right and if a distance

723
00:32:56,560 --> 00:32:54,679
it has to travel is larger than its

724
00:32:59,169 --> 00:32:56,570
speed times the amount of time it's

725
00:33:01,299 --> 00:32:59,179
allowed to travel what the problem is is

726
00:33:03,010 --> 00:33:01,309
the lights just not reaching us and that

727
00:33:05,620 --> 00:33:03,020
turned out to be the solution to the

728
00:33:07,450 --> 00:33:05,630
paradox right that there's some time the

729
00:33:09,400 --> 00:33:07,460
the darkness and I sky is due to the

730
00:33:13,659 --> 00:33:09,410
fact that we just haven't received light

731
00:33:15,430 --> 00:33:13,669
from there yet and if you want to think

732
00:33:19,570 --> 00:33:15,440
about this a little bit further and

733
00:33:22,659 --> 00:33:19,580
imagine the universe as this glowing

734
00:33:25,180 --> 00:33:22,669
sphere with a luminosity density and a

735
00:33:27,370 --> 00:33:25,190
radius that's equal to the speed of

736
00:33:29,409 --> 00:33:27,380
light C times T not the amount of time

737
00:33:32,380 --> 00:33:29,419
it's been allowed to travel here we say

738
00:33:35,680 --> 00:33:32,390

it is T not is the age of the universe

739
00:33:38,080 --> 00:33:35,690
about 14 billion years old we can relate

740
00:33:41,440 --> 00:33:38,090
the luminosity and the distance it's

741
00:33:44,890 --> 00:33:41,450
gone to intensity the intensity of this

742
00:33:46,570 --> 00:33:44,900
very far distant light called as we call

743
00:33:48,640 --> 00:33:46,580
extra galactic background light light

744
00:33:52,870 --> 00:33:48,650
from very foreign distant distant

745
00:33:56,200 --> 00:33:52,880
sources and to touch upon the EBL real

746
00:33:57,760 --> 00:33:56,210
quickly when we first discovered it we

747
00:33:59,409 --> 00:33:57,770
discovered it from a quasar that I

748
00:34:01,240 --> 00:33:59,419
believe was about seven point six

749
00:34:02,950 --> 00:34:01,250
billion light years away so this thing's

750
00:34:05,230 --> 00:34:02,960
about more than half the age of the

751
00:34:08,440 --> 00:34:05,240
universe and when we detected it in

752
00:34:10,960 --> 00:34:08,450
space of course we detected it as what

753
00:34:13,260 --> 00:34:10,970
we call a gamma-ray photon gamma-ray

754
00:34:15,730 --> 00:34:13,270
photons are very highly energetic

755
00:34:18,970 --> 00:34:15,740
photons they have very short wavelengths

756
00:34:22,750 --> 00:34:18,980
and this raised a lot of eyebrows right

757
00:34:24,369 --> 00:34:22,760
this thing travelled of like more than

758
00:34:26,950 --> 00:34:24,379
half the age of the universe to reach us

759
00:34:29,940 --> 00:34:26,960
and even with cosmic expansion affecting

760
00:34:32,460 --> 00:34:29,950
the photon in elongating its wavelength

761
00:34:34,599 --> 00:34:32,470
we're still reading it in as a gamma ray

762
00:34:36,899 --> 00:34:34,609
you know it would make sense you know if

763
00:34:39,190 --> 00:34:36,909

I drove my car from here to California

764
00:34:41,290 --> 00:34:39,200
I'd have a better chance of getting into

765
00:34:42,940 --> 00:34:41,300
a car accident then if I were to just

766
00:34:44,859 --> 00:34:42,950
drive it from here down the street and

767
00:34:46,930 --> 00:34:44,869
back of course that depends on how good

768
00:34:49,349 --> 00:34:46,940
of a driver I am but that's another

769
00:34:55,680 --> 00:34:52,149
but the same thing applies something

770
00:34:59,380 --> 00:34:55,690
traveling this great amount of distance

771
00:35:01,210 --> 00:34:59,390
really made us see just how empty space

772
00:35:03,940 --> 00:35:01,220
is right it's not hitting anything it's

773
00:35:05,829 --> 00:35:03,950
not getting caught in any dust or any

774
00:35:10,120 --> 00:35:05,839
other particle floating out in space

775
00:35:12,910 --> 00:35:10,130
though it actually hints at how just how

776
00:35:14,950 --> 00:35:12,920
empty space really is and it's quite a

777
00:35:19,029 --> 00:35:14,960
wonderful thing to contemplate for a

778
00:35:22,480 --> 00:35:19,039
second so moving on to how this worked

779
00:35:23,589 --> 00:35:22,490
in with my summer research was we wanted

780
00:35:25,240 --> 00:35:23,599
to go out and see if we could measure

781
00:35:27,130 --> 00:35:25,250
this intensity from the extra galactic

782
00:35:28,900 --> 00:35:27,140
background light because by doing that

783
00:35:30,759 --> 00:35:28,910
we can then make inferences about the

784
00:35:32,440 --> 00:35:30,769
age of the universe because this has

785
00:35:34,299 --> 00:35:32,450
travelled such a large distance it's

786
00:35:36,130 --> 00:35:34,309
holding information about how long it's

787
00:35:39,549 --> 00:35:36,140
traveled that T not I would like to know

788
00:35:40,299 --> 00:35:39,559

and so what you see here is that nice

789
00:35:43,569 --> 00:35:40,309
pink bluey

790
00:35:45,759 --> 00:35:43,579
picture that is a image we took from the

791
00:35:47,710 --> 00:35:45,769
Towson University 16 inch telescope and

792
00:35:50,499 --> 00:35:47,720
underneath it is another ground-based

793
00:35:54,460 --> 00:35:50,509
image of where the Hubble Deep Field is

794
00:35:56,410 --> 00:35:54,470
inside the Big Dipper and we're actually

795
00:35:59,559 --> 00:35:56,420
aiming for the Hubble Deep Field and as

796
00:36:01,089 --> 00:35:59,569
you can see we just we just missed it by

797
00:36:03,609 --> 00:36:01,099
a little bit they always say when you're

798
00:36:05,230 --> 00:36:03,619
planning when you're planning telescope

799
00:36:05,529 --> 00:36:05,240
time you pick three days you lose one to

800
00:36:07,480 --> 00:36:05,539
weather

801
00:36:09,670 --> 00:36:07,490
one to technical difficulties and by the

802
00:36:12,130 --> 00:36:09,680
third hopefully you get something so

803
00:36:15,130 --> 00:36:12,140
this falls under technical difficulties

804
00:36:17,289 --> 00:36:15,140
but luckily we planned ahead and we had

805
00:36:19,599 --> 00:36:17,299
multiple days but it was still a good

806
00:36:22,089 --> 00:36:19,609
practice to use this to do data

807
00:36:23,289 --> 00:36:22,099
calibration image reduction all these

808
00:36:27,400 --> 00:36:23,299
things you don't think about until

809
00:36:29,710 --> 00:36:27,410
you're in doing the project but it was

810
00:36:31,359 --> 00:36:29,720
also taken near new moon so we wanted to

811
00:36:33,400 --> 00:36:31,369
reduce the amount of light in our image

812
00:36:34,990 --> 00:36:33,410
because what we were looking at was

813
00:36:37,120 --> 00:36:35,000

something very far in distance so we

814
00:36:38,920 --> 00:36:37,130
didn't want light from close objects

815
00:36:40,930 --> 00:36:38,930
getting in the way and if you're curious

816
00:36:43,059 --> 00:36:40,940
it was taken in the our band filter what

817
00:36:44,920 --> 00:36:43,069
that is is exactly as it sounds it's a

818
00:36:47,140 --> 00:36:44,930
filter that you strap on to your

819
00:36:49,450 --> 00:36:47,150
telescope and you tell it hey I know you

820
00:36:51,880 --> 00:36:49,460
can read in multiple wavelengths but I

821
00:36:54,069 --> 00:36:51,890
only want you to look in this set of

822
00:36:57,579 --> 00:36:54,079
wavelengths this range that way you

823
00:36:59,440 --> 00:36:57,589
don't that way you don't get light from

824
00:37:02,430 --> 00:36:59,450
other wavelengths that you don't care

825
00:37:06,880 --> 00:37:02,440
about basically right so

826
00:37:08,890 --> 00:37:06,890
going into what we actually saw so we

827
00:37:10,539 --> 00:37:08,900
estimated assuming that the age of the

828
00:37:12,160 --> 00:37:10,549
universe was about fourteen billion

829
00:37:14,109 --> 00:37:12,170
years old we estimated that the

830
00:37:15,819 --> 00:37:14,119
intensity of this extra galactic

831
00:37:17,170 --> 00:37:15,829
background light should be about three

832
00:37:19,839 --> 00:37:17,180
nano watts per meter squared per

833
00:37:21,220 --> 00:37:19,849
steradian and that its luminosity should

834
00:37:24,640 --> 00:37:21,230
be about three times 10 to the negative

835
00:37:26,260 --> 00:37:24,650
33 watts per meter cubed and what we

836
00:37:28,450 --> 00:37:26,270
actually saw was what you get from

837
00:37:31,930 --> 00:37:28,460
telescopes did you get counts per pixel

838
00:37:34,779 --> 00:37:31,940

which then you have to go and convert

839
00:37:36,700 --> 00:37:34,789
into the unit's you want and so we

840
00:37:38,890 --> 00:37:36,710
converted it into ten thousand plus or

841
00:37:40,750 --> 00:37:38,900
minus five thousand nano watts per meter

842
00:37:44,430 --> 00:37:40,760
squared priests are radiant now if you

843
00:37:46,839 --> 00:37:44,440
like hey you thought you would see three

844
00:37:50,289 --> 00:37:46,849
but she's getting ten thousand who is

845
00:37:50,680 --> 00:37:50,299
this shake what's she doing and you're

846
00:37:52,569 --> 00:37:50,690
right

847
00:37:56,109 --> 00:37:52,579
ten thousand is a big number compared to

848
00:37:59,230 --> 00:37:56,119
three right so what what the heck

849
00:38:01,569 --> 00:37:59,240
happened and I'll tell you what happened

850
00:38:05,049 --> 00:38:01,579
being a ground-based telescope you're

851
00:38:06,849 --> 00:38:05,059
fighting a lot of light pollution inside

852
00:38:09,010 --> 00:38:06,859
Earth's atmosphere before you even get

853
00:38:11,769 --> 00:38:09,020
outside of it right so what we had to do

854
00:38:13,990 --> 00:38:11,779
we had to sit down and quantify you know

855
00:38:17,710 --> 00:38:14,000
the amounts of light pollution adding to

856
00:38:21,190 --> 00:38:17,720
our image from each different source of

857
00:38:23,740 --> 00:38:21,200
light and after we subtracted through

858
00:38:25,809 --> 00:38:23,750
subtracted out all those extra sources

859
00:38:28,000 --> 00:38:25,819
of light we actually ended up with a

860
00:38:29,559 --> 00:38:28,010
really nice number of a hundred nano

861
00:38:31,750 --> 00:38:29,569
watts per meter square per steradian and

862
00:38:34,539 --> 00:38:31,760
this is much closer to our estimated

863
00:38:38,049 --> 00:38:34,549

amount so it was quite a success and if

864
00:38:40,240 --> 00:38:38,059
you're wondering what that little map of

865
00:38:42,160 --> 00:38:40,250
Maryland is over there that is an image

866
00:38:44,349 --> 00:38:42,170
called the bortles scale

867
00:38:47,589 --> 00:38:44,359
now the bordel scale tries to quantify

868
00:38:50,079 --> 00:38:47,599
the amount of light pollution where you

869
00:38:52,990 --> 00:38:50,089
are geographically and it scales from

870
00:38:55,329 --> 00:38:53,000
one to nine about one to nine and one is

871
00:38:58,569 --> 00:38:55,339
represented as black about nine is

872
00:39:00,760 --> 00:38:58,579
represented at what as white white being

873
00:39:03,579 --> 00:39:00,770
the worst black being the best and if

874
00:39:05,890 --> 00:39:03,589
any of you have no idea what Towson or

875
00:39:09,820 --> 00:39:05,900
Baltimore is that's okay just look at

876
00:39:15,850 --> 00:39:13,930
yeah it's it would make sense though

877
00:39:18,130 --> 00:39:15,860
that you know in one of the most highly

878
00:39:20,380 --> 00:39:18,140
like polluted areas in Maryland our data

879
00:39:24,760 --> 00:39:20,390
would be off because there's so much

880
00:39:26,920 --> 00:39:24,770
light pollution right so in the end of

881
00:39:29,680 --> 00:39:26,930
this project out over abouts we

882
00:39:31,450 --> 00:39:29,690
collected about 70,000 photons over a

883
00:39:34,420 --> 00:39:31,460
thirty minute exposure the amount of

884
00:39:36,310 --> 00:39:34,430
time we left our telescope open and we

885
00:39:39,220 --> 00:39:36,320
can say approximately about twenty of

886
00:39:42,940 --> 00:39:39,230
them actually belonged to the EBL so it

887
00:39:45,220 --> 00:39:42,950
was quite quite a fun project learned a

888
00:39:49,900 --> 00:39:45,230

lot about why why we want to launch

889
00:39:54,730 --> 00:39:49,910
things up into space right ground base

890
00:39:56,470 --> 00:39:54,740
is is ground-based but it's it's really

891
00:39:59,530 --> 00:39:56,480
it was really a great learning

892
00:40:01,930 --> 00:39:59,540
experience and opportunity the other

893
00:40:03,970 --> 00:40:01,940
half of my summer was spent actually

894
00:40:06,880 --> 00:40:03,980
looking for light deflection during the

895
00:40:08,980 --> 00:40:06,890
2017 solar eclipse and in these images

896
00:40:10,450 --> 00:40:08,990
you'll see Chris misko hits with his

897
00:40:12,160 --> 00:40:10,460
telescope down and so all these were

898
00:40:15,820 --> 00:40:12,170
taken in South Carolina but you'll see

899
00:40:17,410 --> 00:40:15,830
him setting up the telescope the middle

900
00:40:18,880 --> 00:40:17,420
one is actually one we took with his

901
00:40:20,440 --> 00:40:18,890
telescope and you'll see you know the

902
00:40:23,350 --> 00:40:20,450
Eclipse in the middle in it transiting

903
00:40:26,320 --> 00:40:23,360
on either end and on the far one you'll

904
00:40:28,510 --> 00:40:26,330
see me under a nice cool tent with some

905
00:40:31,570 --> 00:40:28,520
ice water and a laptop in front of me I

906
00:40:36,160 --> 00:40:31,580
chose the right job for the end of

907
00:40:39,040 --> 00:40:36,170
August at 2:00 p.m. that is his personal

908
00:40:40,780 --> 00:40:39,050
telescope I know right I am very

909
00:40:46,960 --> 00:40:40,790
surprised he let me as close to it as he

910
00:40:48,490 --> 00:40:46,970
did it's just a telescope yep he would

911
00:40:52,480 --> 00:40:48,500
have think he would have thought but

912
00:40:54,610 --> 00:40:52,490
yeah yeah so I spent my so I we it was a

913
00:40:57,790 --> 00:40:54,620

very stressful time you know we only had

914
00:40:59,740 --> 00:40:57,800
two minutes to take these images that we

915
00:41:00,940 --> 00:40:59,750
needed and you know everything had to be

916
00:41:02,950 --> 00:41:00,950
perfect everything had to be right

917
00:41:04,300 --> 00:41:02,960
clouds were coming in threatening and I

918
00:41:11,620 --> 00:41:04,310
got really anxious I was like you better

919
00:41:13,540 --> 00:41:11,630
met her move and and yeah and so from

920
00:41:15,490 --> 00:41:13,550
inside the tent I what I was doing was

921
00:41:17,890 --> 00:41:15,500
we were setting out we were calibrating

922
00:41:20,560 --> 00:41:17,900
the telescope I was basically saying

923
00:41:21,470 --> 00:41:20,570
move it a little left no the other left

924
00:41:27,440 --> 00:41:21,480
you

925
00:41:30,589 --> 00:41:27,450
Eclipse along the line of totality I do

926
00:41:34,010 --> 00:41:30,599
have a video for you taken by CNN that

927
00:41:37,220 --> 00:41:34,020
map that shows the solar eclipse as it's

928
00:41:39,020 --> 00:41:37,230
going through North America right so it

929
00:41:40,970 --> 00:41:39,030
starts up in Washington and ends up in

930
00:41:51,890 --> 00:41:40,980
South Carolina so it's a really cool

931
00:42:06,470 --> 00:41:51,900
video so here you guys go it had sound

932
00:42:57,509 --> 00:42:06,480
but it use your imagination right well I

933
00:43:02,799 --> 00:43:00,400
so it was a little video it's actually

934
00:43:06,039 --> 00:43:02,809
funny cuz I'm I went down to Lexington

935
00:43:07,569 --> 00:43:06,049
South Carolina and I was going down of

936
00:43:09,759 --> 00:43:07,579
course to do some imaging and research

937
00:43:11,589 --> 00:43:09,769
and afterwards I was gonna meet up with

938
00:43:13,959 --> 00:43:11,599

some friends down at Myrtle Beach who

939
00:43:16,390 --> 00:43:13,969
drove two hours inward you know to view

940
00:43:17,319 --> 00:43:16,400
the solar eclipse and everything went

941
00:43:19,630 --> 00:43:17,329
wrong you know they couldn't get into

942
00:43:21,339 --> 00:43:19,640
the parks cuz you know it was backed up

943
00:43:26,289 --> 00:43:21,349
since like 2:00 a.m. the night before

944
00:43:27,910 --> 00:43:26,299
and they actually met a guy there who

945
00:43:29,199 --> 00:43:27,920
like brought him to this special spot

946
00:43:31,140 --> 00:43:29,209
where he was like building cabins or

947
00:43:33,099 --> 00:43:31,150
something it was kind of sketchy but

948
00:43:35,259 --> 00:43:33,109
regardless to say they had clear skies

949
00:43:37,589 --> 00:43:35,269
and some of my friends had some small

950
00:43:40,870 --> 00:43:37,599
telescopes where they could view it and

951
00:43:45,039 --> 00:43:40,880
as soon as transit started it clouds

952
00:43:47,370 --> 00:43:45,049
came in and rained on them so one of our

953
00:43:50,259 --> 00:43:47,380
friends in the group chat decided to

954
00:43:54,339 --> 00:43:50,269
change the image of the group chat from

955
00:43:57,549 --> 00:43:54,349
a solar eclipse to clouded cloudy cloudy

956
00:44:01,989 --> 00:43:57,559
to a cloudy sky it did not go over well

957
00:44:05,109 --> 00:44:01,999
let's just say hey but you know eclipse

958
00:44:06,729 --> 00:44:05,119
is as beautiful as they are what what I

959
00:44:09,429 --> 00:44:06,739
was down there for was what was

960
00:44:11,739 --> 00:44:09,439
happening behind the scenes right so

961
00:44:13,449 --> 00:44:11,749
what what is happening behind the scenes

962
00:44:15,819 --> 00:44:13,459
well something called gravitational

963
00:44:18,609 --> 00:44:15,829

light deflection right we in general

964
00:44:20,319 --> 00:44:18,619
relativity we believe that gravity is

965
00:44:22,599 --> 00:44:20,329
equal to the warping of space-time so

966
00:44:24,759 --> 00:44:22,609
what's keeping me on this floor is not

967
00:44:27,729 --> 00:44:24,769
some force gravity it's the fact that

968
00:44:29,620 --> 00:44:27,739
the earth is massive and it's it's

969
00:44:32,109 --> 00:44:29,630
dipping into the fabric of space-time

970
00:44:33,669 --> 00:44:32,119
causing this little war and this inward

971
00:44:36,189 --> 00:44:33,679
warp is what's holding me down so

972
00:44:39,669 --> 00:44:36,199
gravity is equal to how much warping is

973
00:44:42,250 --> 00:44:39,679
done to space-time and what happens to

974
00:44:44,800 --> 00:44:42,260
light when this happens is

975
00:44:47,050 --> 00:44:44,810
light actually wants to travel on a

976
00:44:49,000 --> 00:44:47,060
straight path but when it gets close

977
00:44:51,430 --> 00:44:49,010
enough to these massive objects and the

978
00:44:54,220 --> 00:44:51,440
warping that has it's done to the fabric

979
00:44:58,030 --> 00:44:54,230
of space-time it's gonna cause the light

980
00:45:02,109 --> 00:44:58,040
to bend and my eyes you can trick him

981
00:45:04,900 --> 00:45:02,119
very easily my eyes on you can trick our

982
00:45:07,090 --> 00:45:04,910
eyes only see in straight lines so if I

983
00:45:09,370 --> 00:45:07,100
have light coming in from over here and

984
00:45:12,760 --> 00:45:09,380
it's curving and it's coming to me like

985
00:45:16,180 --> 00:45:12,770
this I don't I don't see that oh though

986
00:45:18,190 --> 00:45:16,190
it's like being bent around the Sun no I

987
00:45:20,290 --> 00:45:18,200
think the star that the lights coming

988
00:45:21,670 --> 00:45:20,300

from the Stars located over here right

989
00:45:22,930 --> 00:45:21,680
if the light's coming here I think the

990
00:45:27,099 --> 00:45:22,940
star is actually over here because I can

991
00:45:29,290 --> 00:45:27,109
only see in straight lines right and so

992
00:45:31,300 --> 00:45:29,300
what I actually ends up happening is a

993
00:45:34,359 --> 00:45:31,310
star's position that we we know is over

994
00:45:37,330 --> 00:45:34,369
here now looks like it's over here right

995
00:45:40,720 --> 00:45:37,340
this deflection is causing an outward

996
00:45:43,090 --> 00:45:40,730
shift in a star's position so if I were

997
00:45:46,510 --> 00:45:43,100
to take the Sun out of this image and

998
00:45:48,790 --> 00:45:46,520
have flat space I would recognize that

999
00:45:50,770 --> 00:45:48,800
the star I was looking at was over here

1000
00:45:53,050 --> 00:45:50,780
but the fact that the sun's in there and

1001
00:45:55,660 --> 00:45:53,060
is warping space-time and the light is

1002
00:45:56,020 --> 00:45:55,670
being bent by it my eyes don't see the

1003
00:45:57,660 --> 00:45:56,030
difference

1004
00:46:02,620 --> 00:45:57,670
he thinks the Stars over here for sure

1005
00:46:04,090 --> 00:46:02,630
but it's not and this is what we wanted

1006
00:46:06,220 --> 00:46:04,100
to go out to see if we could see this in

1007
00:46:08,530 --> 00:46:06,230
the 2017 solar eclipse all right so

1008
00:46:11,320 --> 00:46:08,540
first we needed an equation this is a

1009
00:46:15,130 --> 00:46:11,330
fancy schmancy equation that basically

1010
00:46:16,540 --> 00:46:15,140
produces deflection of my light right

1011
00:46:19,060 --> 00:46:16,550
and this is done through a program

1012
00:46:21,280 --> 00:46:19,070
called Stellarium it is a planetary

1013
00:46:22,750 --> 00:46:21,290

program and it's you know it's made by

1014
00:46:26,170 --> 00:46:22,760
astronomers when there's a button to

1015
00:46:29,200 --> 00:46:26,180
take out the atmosphere so you can see

1016
00:46:31,510 --> 00:46:29,210
everything very nicely and what we

1017
00:46:34,090 --> 00:46:31,520
needed was two stars close enough to the

1018
00:46:35,650 --> 00:46:34,100
Sun that they would undergo this

1019
00:46:39,520 --> 00:46:35,660
deflection of light and it just so

1020
00:46:41,109 --> 00:46:39,530
happens there were two stars that would

1021
00:46:46,960 --> 00:46:41,119
be perfect candidates to undergo this

1022
00:46:49,390 --> 00:46:46,970
light deflection so it's also noteworthy

1023
00:46:52,330 --> 00:46:49,400
to mention that these two stars are both

1024
00:46:54,190 --> 00:46:52,340
what we call 7th magnitude stars which

1025
00:46:55,549 --> 00:46:54,200
means they're very very dim so in

1026
00:46:57,920 --> 00:46:55,559
astronomy

1027
00:46:59,299 --> 00:46:57,930
have this ridiculous scale that says the

1028
00:47:01,249 --> 00:46:59,309
brighter the star is the lower the

1029
00:47:03,049 --> 00:47:01,259
number magnitude it is so if I have like

1030
00:47:05,029 --> 00:47:03,059
a two magnitude star that means it's

1031
00:47:07,009 --> 00:47:05,039
very bright compared to a seventh or a

1032
00:47:08,539 --> 00:47:07,019
10th magnitude star which is very faint

1033
00:47:10,640 --> 00:47:08,549
I didn't make the rules

1034
00:47:12,170 --> 00:47:10,650
I just follow them maybe one of you guys

1035
00:47:16,039 --> 00:47:12,180
can come up with a better way of scaling

1036
00:47:18,259 --> 00:47:16,049
our stars but it's it's what we normally

1037
00:47:21,799 --> 00:47:18,269
use so that's what it means by 7th

1038
00:47:23,719 --> 00:47:21,809

magnitude since they both lie on the

1039
00:47:25,880 --> 00:47:23,729
opposite side of the Sun we must be

1040
00:47:29,209 --> 00:47:25,890
measured we estimated a total angular

1041
00:47:31,910 --> 00:47:29,219
separation of about 0.2 for arc seconds

1042
00:47:38,870 --> 00:47:31,920
which is potentially measurable with

1043
00:47:41,719 --> 00:47:38,880
with our equipment so this is not what

1044
00:47:44,839 --> 00:47:41,729
we this is what we saw but what you see

1045
00:47:47,269 --> 00:47:44,849
here is actually um our telescope

1046
00:47:48,920 --> 00:47:47,279
decided you know I'm not gonna work for

1047
00:47:51,769 --> 00:47:48,930
the most important part of your project

1048
00:47:52,339 --> 00:47:51,779
I'm just gonna conk out and not do what

1049
00:48:00,439 --> 00:47:52,349
I'm told

1050
00:48:02,029 --> 00:48:00,449
so yeah images look cool but they didn't

1051
00:48:04,789 --> 00:48:02,039
have what we needed in them which was

1052
00:48:07,099 --> 00:48:04,799
the Stars to measure to see if this

1053
00:48:09,709 --> 00:48:07,109
deflection actually happened occurred

1054
00:48:11,029 --> 00:48:09,719
but this is an image and I got

1055
00:48:13,549 --> 00:48:11,039
permission to use this image in my

1056
00:48:17,479 --> 00:48:13,559
project from Miss lob drum from Euler

1057
00:48:19,579 --> 00:48:17,489
he's a he comes from the Czech Republic

1058
00:48:22,400 --> 00:48:19,589
and he photographs his photographs

1059
00:48:26,150 --> 00:48:22,410
eclipses and if you just you know Google

1060
00:48:28,130 --> 00:48:26,160
2017 solar eclipse miss la France Mila

1061
00:48:30,380 --> 00:48:28,140
he has tons of eclipses and not just

1062
00:48:31,969 --> 00:48:30,390
from 2017 and if you have a chance it's

1063
00:48:34,189 --> 00:48:31,979

really worth just pulling up on your

1064
00:48:35,900 --> 00:48:34,199
computer because I don't know if you

1065
00:48:37,819 --> 00:48:35,910
probably can't see but there's a ton of

1066
00:48:39,829 --> 00:48:37,829
stars and this and you can probably see

1067
00:48:41,839 --> 00:48:39,839
you can even see some of the cratering

1068
00:48:44,419 --> 00:48:41,849
in the moon from the light being

1069
00:48:47,719 --> 00:48:44,429
reflected off earth back to it so it's

1070
00:48:50,029 --> 00:48:47,729
quite a beautiful image and it works

1071
00:48:51,709 --> 00:48:50,039
perfectly for us because it has

1072
00:48:54,829 --> 00:48:51,719
everything we need in it right first

1073
00:48:57,199 --> 00:48:54,839
step one we got to identify our target

1074
00:49:00,739 --> 00:48:57,209
stars that we found in stellarium which

1075
00:49:02,959 --> 00:49:00,749
with his image their star a GM leo and

1076
00:49:04,609 --> 00:49:02,969
star b HD eight six eight nine eight

1077
00:49:07,910 --> 00:49:04,619
what a phone number

1078
00:49:09,009 --> 00:49:07,920
stars tend to have we have a lot of

1079
00:49:11,289 --> 00:49:09,019
catalogs we

1080
00:49:15,429 --> 00:49:11,299
give a lot of names to the same thing so

1081
00:49:16,719 --> 00:49:15,439
if you're wondering hey you know it says

1082
00:49:18,549 --> 00:49:16,729
it's this star it's just probably

1083
00:49:20,639 --> 00:49:18,559
because that star is being named through

1084
00:49:23,949 --> 00:49:20,649
another catalog but it's the same start

1085
00:49:25,479 --> 00:49:23,959
the next step is that in order to

1086
00:49:26,589 --> 00:49:25,489
transform the image into our a deck

1087
00:49:28,929 --> 00:49:26,599
which is right Ascension and declination

1088
00:49:31,539 --> 00:49:28,939

it's basically how we locate things in

1089
00:49:33,549 --> 00:49:31,549
the sky we need to use some reference

1090
00:49:35,199 --> 00:49:33,559
stars stars far enough away from this

1091
00:49:36,999 --> 00:49:35,209
eclipse that their positions aren't

1092
00:49:40,539 --> 00:49:37,009
going to be altered and they're gonna be

1093
00:49:42,370 --> 00:49:40,549
fine everything's gonna be great so the

1094
00:49:44,319 --> 00:49:42,380
more spread-out they are the better my

1095
00:49:46,299 --> 00:49:44,329
solution turned out to be so we picked

1096
00:49:50,079 --> 00:49:46,309
some very far stars there's that star

1097
00:49:53,289 --> 00:49:50,089
that star C D and E again with their

1098
00:49:56,319 --> 00:49:53,299
lovely phone numbers identifying them so

1099
00:49:57,849 --> 00:49:56,329
step three all we got to do now is find

1100
00:49:59,709 --> 00:49:57,859
the ings angular separation between a

1101
00:50:02,199 --> 00:49:59,719
and B and care pair it to what I

1102
00:50:06,029 --> 00:50:02,209
predicted right easy peasy lemon squeezy

1103
00:50:09,059 --> 00:50:06,039
I was so wrong

1104
00:50:10,989 --> 00:50:09,069
so what mate this was probably I

1105
00:50:12,609 --> 00:50:10,999
wouldn't say the most stressful cuz the

1106
00:50:15,089 --> 00:50:12,619
most stressful is always setting up the

1107
00:50:17,229 --> 00:50:15,099
telescope making sure it works but um

1108
00:50:21,579 --> 00:50:17,239
this was definitely one of the more

1109
00:50:24,579 --> 00:50:21,589
gruesome parts of the the research was

1110
00:50:28,089 --> 00:50:24,589
that this image had to be transformed

1111
00:50:29,639 --> 00:50:28,099
from XY coordinates pixel by pixel into

1112
00:50:34,749 --> 00:50:29,649
our a right Ascension and declination

1113
00:50:36,999 --> 00:50:34,759

locations and and it a lot of things had

1114
00:50:39,009 --> 00:50:37,009
to happen to it so what you see here are

1115
00:50:41,769 --> 00:50:39,019
some transformation equations that we

1116
00:50:44,969 --> 00:50:41,779
needed that we made to account for the

1117
00:50:47,949 --> 00:50:44,979
fact that one my origin needs to change

1118
00:50:51,120 --> 00:50:47,959
to beta is my scaling factor the factor

1119
00:50:55,149 --> 00:50:51,130
that I'm going to multiply in to turn my

1120
00:50:56,889 --> 00:50:55,159
my number that I get out into degrees

1121
00:51:00,219 --> 00:50:56,899
argument its arc seconds that sort of

1122
00:51:02,199 --> 00:51:00,229
thing and the Phi is represented by the

1123
00:51:03,789 --> 00:51:02,209
angle I had a rotated by so the reason

1124
00:51:06,479 --> 00:51:03,799
I'm doing this in the first place is

1125
00:51:10,049 --> 00:51:06,489
because if I kept the picture horizontal

1126
00:51:13,359 --> 00:51:10,059
Michael acting north would not match up

1127
00:51:16,089 --> 00:51:13,369
with a cataloged galactic North which

1128
00:51:17,439 --> 00:51:16,099
would mean yeah I could produce some

1129
00:51:18,939 --> 00:51:17,449
numbers but I couldn't compare to

1130
00:51:21,159 --> 00:51:18,949
anything I would have to make up my own

1131
00:51:22,779 --> 00:51:21,169
things I'd have to do all this stuff so

1132
00:51:23,110 --> 00:51:22,789
I have to manipulate my photos so that

1133
00:51:27,340 --> 00:51:23,120
it

1134
00:51:29,080 --> 00:51:27,350
galactic north being up and that that

1135
00:51:30,850 --> 00:51:29,090
now my reference star is I can identify

1136
00:51:33,580 --> 00:51:30,860
them through the catalog and use those

1137
00:51:36,820 --> 00:51:33,590
locations so everything's good fine and

1138
00:51:38,140 --> 00:51:36,830

dandy right so do this this gives me

1139
00:51:40,540 --> 00:51:38,150
four unknowns that I don't know about

1140
00:51:43,180 --> 00:51:40,550
right this Alpha Delta this new origin

1141
00:51:45,040 --> 00:51:43,190
of my image the beta the scaling factor

1142
00:51:47,020 --> 00:51:45,050
I'm going to need to multiply in and Phi

1143
00:51:49,570 --> 00:51:47,030
the angle I'm gonna have to rotate my

1144
00:51:53,800 --> 00:51:49,580
picture by but not all hope is lost

1145
00:51:57,130 --> 00:51:53,810
because I have reference stars yay and I

1146
00:51:59,260 --> 00:51:57,140
can get all of these unknowns by

1147
00:52:01,510 --> 00:51:59,270
applying them to the reference stars the

1148
00:52:04,210 --> 00:52:01,520
stars that have not been changed by

1149
00:52:07,210 --> 00:52:04,220
gravitational lensing so once I find

1150
00:52:08,980 --> 00:52:07,220
them for the for the reference stars I

1151
00:52:12,570 --> 00:52:08,990
can go back to my target stars the two

1152
00:52:16,890 --> 00:52:12,580
stars I believe are going going through

1153
00:52:21,490 --> 00:52:16,900
gravitational lensing and move change

1154
00:52:26,620 --> 00:52:21,500
transform their coordinates so this

1155
00:52:29,590 --> 00:52:26,630
involve some spherical trig yeah three

1156
00:52:31,270 --> 00:52:29,600
Oracle trig good stuff all you need to

1157
00:52:33,160 --> 00:52:31,280
know is that you know the basic

1158
00:52:35,020 --> 00:52:33,170
trigonometry you you're taught in high

1159
00:52:35,920 --> 00:52:35,030
school or middle school I don't know

1160
00:52:37,150 --> 00:52:35,930
they teach them like when they're

1161
00:52:41,530 --> 00:52:37,160
practically elementary schools these

1162
00:52:44,860 --> 00:52:41,540
days I don't know but all you need to

1163
00:52:46,960 --> 00:52:44,870

know is that you know when we do regular

1164
00:52:48,880 --> 00:52:46,970
trigonometry with right angles and

1165
00:52:50,770 --> 00:52:48,890
hypotenuse right we're normally doing

1166
00:52:53,290 --> 00:52:50,780
that on a flat surface on like a 2d

1167
00:52:54,910 --> 00:52:53,300
image of a triangle as such well

1168
00:52:58,840 --> 00:52:54,920
spherical tree game about because you

1169
00:53:01,780 --> 00:52:58,850
know we we don't live in a flat universe

1170
00:53:03,520 --> 00:53:01,790
we can't use flat equations on something

1171
00:53:05,980 --> 00:53:03,530
that's three-dimensional so this takes

1172
00:53:08,950 --> 00:53:05,990
into the idea that we're applying

1173
00:53:10,630 --> 00:53:08,960
trigonometry but to stuff that is curved

1174
00:53:14,920 --> 00:53:10,640
that's not flat that's in three

1175
00:53:19,090 --> 00:53:14,930
dimensions right so I result in the

1176
00:53:22,240 --> 00:53:19,100
deflected light came up to be 22900 five

1177
00:53:25,690 --> 00:53:22,250
days 57 plus or minus 29 arc seconds and

1178
00:53:29,380 --> 00:53:25,700
deflected and then the actual separation

1179
00:53:31,150 --> 00:53:29,390
the undeflected light being about 2953

1180
00:53:32,950 --> 00:53:31,160
arc seconds and what I want to do is I

1181
00:53:35,060 --> 00:53:32,960
want to take the difference of this to

1182
00:53:38,000 --> 00:53:35,070
match it to the difference of the

1183
00:53:40,780 --> 00:53:38,010
separation I produced in my prediction

1184
00:53:43,820 --> 00:53:40,790
to see if their clothes are compatible

1185
00:53:45,680 --> 00:53:43,830
after doing the math I get four arc

1186
00:53:48,380 --> 00:53:45,690
seconds which is consistent with general

1187
00:53:51,560 --> 00:53:48,390
relativity and is very close to my

1188
00:53:53,750 --> 00:53:51,570

predicted difference in deflection which

1189
00:53:57,380 --> 00:53:53,760
was two point four seconds so this was

1190
00:53:59,750 --> 00:53:57,390
very much a success you might be saying

1191
00:54:02,900 --> 00:53:59,760
hey Herrera bar is pretty high there you

1192
00:54:04,970 --> 00:54:02,910
know just like the last one but what

1193
00:54:07,700 --> 00:54:04,980
actually ended up happening was my

1194
00:54:09,910 --> 00:54:07,710
mentor and I were not fluent in like

1195
00:54:12,320 --> 00:54:09,920
coding languages such as Python or

1196
00:54:15,170 --> 00:54:12,330
manipulation through ds9 and this image

1197
00:54:17,120 --> 00:54:15,180
was not given to us as like a fits in

1198
00:54:19,880 --> 00:54:17,130
astronomy there's these file it's just

1199
00:54:21,320 --> 00:54:19,890
like another type of image file you get

1200
00:54:24,860 --> 00:54:21,330
you get something sent to you by like

1201
00:54:26,960 --> 00:54:24,870
JPEG or PDF well in astronomy we have

1202
00:54:28,970 --> 00:54:26,970
this thing called Fitz and normally why

1203
00:54:30,500 --> 00:54:28,980
we do it through Fitz is because there's

1204
00:54:32,930 --> 00:54:30,510
a lot of information about like where

1205
00:54:35,120 --> 00:54:32,940
the what telescope took this image you

1206
00:54:38,960 --> 00:54:35,130
know where it was taken all sorts of

1207
00:54:41,120 --> 00:54:38,970
things like that but that make the data

1208
00:54:44,930 --> 00:54:41,130
calculator his life so much easier but

1209
00:54:46,310 --> 00:54:44,940
this image was like a JPEG so I so

1210
00:54:49,370 --> 00:54:46,320
everything had to be done manually

1211
00:54:50,990 --> 00:54:49,380
including the calculation so this we my

1212
00:54:53,810 --> 00:54:51,000
mentor and I actually sat down and did

1213
00:54:54,980 --> 00:54:53,820

this calculation so and we yes we were

1214
00:54:57,170 --> 00:54:54,990
rushing because we were very eager to

1215
00:54:59,990 --> 00:54:57,180
see if we saw some deflection in light

1216
00:55:01,160 --> 00:55:00,000
which we did if we go back and do it a

1217
00:55:03,310 --> 00:55:01,170
little more careful I'm sure we can get

1218
00:55:06,260 --> 00:55:03,320
that error about their error bar down

1219
00:55:08,540 --> 00:55:06,270
but it's important to note that we are

1220
00:55:09,980 --> 00:55:08,550
detecting an angle deflection deflection

1221
00:55:12,380 --> 00:55:09,990
in light I should say and that that's

1222
00:55:14,240 --> 00:55:12,390
consistent with general relativity so

1223
00:55:16,970 --> 00:55:14,250
it's quite a spectacular thing and I'm

1224
00:55:20,480 --> 00:55:16,980
told I was just told this earlier today

1225
00:55:23,360 --> 00:55:20,490
that the next 30 years worth of eclipses

1226
00:55:26,030 --> 00:55:23,370
there are no stars close enough to the

1227
00:55:28,880 --> 00:55:26,040
eclipses where you'll be able to do this

1228
00:55:34,530 --> 00:55:28,890
sort of thing to it so we struck why the

1229
00:55:42,360 --> 00:55:34,540
iron was hot and voila so

1230
00:55:43,950 --> 00:55:42,370
thank you just some just some

1231
00:55:46,380 --> 00:55:43,960
last-minute acknowledgments I'd like to

1232
00:55:48,810 --> 00:55:46,390
thank my mentor dr. James overdoing for

1233
00:55:50,510 --> 00:55:48,820
you know getting me involved and this

1234
00:55:52,800 --> 00:55:50,520
was an experience of a lifetime

1235
00:55:53,910 --> 00:55:52,810
Alexander stores dr. Alexander stories

1236
00:55:56,460 --> 00:55:53,920
he helped to Christmas Kuwait's

1237
00:55:58,350 --> 00:55:56,470
telescope a he was so nice he let us

1238
00:55:59,730 --> 00:55:58,360

borrow his equipment and again the

1239
00:56:01,110 --> 00:55:59,740
Maryland Space Grant consortium the

1240
00:56:03,750 --> 00:56:01,120
people right across the street for

1241
00:56:06,150 --> 00:56:03,760
funding this whole thing because this

1242
00:56:07,710 --> 00:56:06,160
whole thing was I was funded and I could

1243
00:56:09,870 --> 00:56:07,720
do it which is great because I don't

1244
00:56:11,460 --> 00:56:09,880
like not being paid for things cuz it's

1245
00:56:14,100 --> 00:56:11,470
hard to live these days and not get paid

1246
00:56:15,870 --> 00:56:14,110
for things and they really they really

1247
00:56:18,780 --> 00:56:15,880
made this whole thing whole shabang

1248
00:56:21,300 --> 00:56:18,790
possible and just one quick last minute

1249
00:56:24,000 --> 00:56:21,310
thing before I take some questions this

1250
00:56:26,880 --> 00:56:24,010
image is also I have permission to use

1251
00:56:29,930 --> 00:56:26,890
it this image was taken by a French

1252
00:56:32,640 --> 00:56:29,940
astronomer his name is John moet and I

1253
00:56:35,430 --> 00:56:32,650
have a bunch of these and these luckily

1254
00:56:38,790 --> 00:56:35,440
are in fits file so it won't be such a

1255
00:56:42,210 --> 00:56:38,800
nightmare going through and I am tasked

1256
00:56:43,620 --> 00:56:42,220
with a senior year capstone going in and

1257
00:56:45,570 --> 00:56:43,630
doing the same sort of treatment and see

1258
00:56:47,550 --> 00:56:45,580
if I can find some light deflection in

1259
00:56:50,880 --> 00:56:47,560
there so this is one of his beautiful

1260
00:56:52,320 --> 00:56:50,890
images of the Eclipse and that's what

1261
00:56:55,140 --> 00:56:52,330
I'll be spending part of my senior year

1262
00:56:56,850 --> 00:56:55,150
doing so thank you very much and all

1263
00:57:02,700 --> 00:56:56,860

except I'll take questions now if any of

1264
00:57:12,220 --> 00:57:05,820
[Applause]

1265
00:57:14,080 --> 00:57:12,230
yeah of course okay so I'm gonna repeat

1266
00:57:16,660 --> 00:57:14,090
the questions for the webcast okay how

1267
00:57:18,610 --> 00:57:16,670
did you start in astronomy it's funny

1268
00:57:24,340 --> 00:57:18,620
you asked I was supposed to be a music

1269
00:57:26,200 --> 00:57:24,350
education major yeah it's quite a it's

1270
00:57:28,660 --> 00:57:26,210
quite a funny story um I spent my first

1271
00:57:30,460 --> 00:57:28,670
year in college you know doing what any

1272
00:57:32,650 --> 00:57:30,470
young Shore College student does take a

1273
00:57:36,070 --> 00:57:32,660
bunch of classes I was very much into

1274
00:57:37,180 --> 00:57:36,080
music and I was preparing to be a music

1275
00:57:40,270 --> 00:57:37,190
ed major so I was learning other

1276
00:57:42,430 --> 00:57:40,280
instruments practicing on my own and I

1277
00:57:44,560 --> 00:57:42,440
just you know Towson forces you to take

1278
00:57:46,690 --> 00:57:44,570
these other classes that aren't related

1279
00:57:49,690 --> 00:57:46,700
to anything else so you become

1280
00:57:53,980 --> 00:57:49,700
well-rounded and well-rounded individual

1281
00:57:56,970 --> 00:57:53,990
so so I wandered up into a general

1282
00:58:00,880 --> 00:57:56,980
astronomy class and I wasn't allowed to

1283
00:58:02,920 --> 00:58:00,890
sign up until the end of registration

1284
00:58:05,710 --> 00:58:02,930
because I was a freshman so the only

1285
00:58:09,940 --> 00:58:05,720
teman are left open was physics and

1286
00:58:11,800 --> 00:58:09,950
metaphysics taught by my mentor and gosh

1287
00:58:14,500 --> 00:58:11,810
boy did I thought I think this was going

1288
00:58:15,910 --> 00:58:14,510

to be awful and it turns out that taking

1289
00:58:18,460 --> 00:58:15,920
those two two classes concurrently

1290
00:58:21,550 --> 00:58:18,470
really made me like oh my gosh this

1291
00:58:23,620 --> 00:58:21,560
stuff is so cool you know and I was I

1292
00:58:26,470 --> 00:58:23,630
was a little nervous because you know

1293
00:58:29,770 --> 00:58:26,480
like I said I was so ready to be a music

1294
00:58:31,930 --> 00:58:29,780
major but um I had a lot of help and

1295
00:58:34,180 --> 00:58:31,940
confidence boosters from from people all

1296
00:58:35,230 --> 00:58:34,190
around me my family my mom she pushed me

1297
00:58:39,310 --> 00:58:35,240
she was like else we just pick something

1298
00:58:43,240 --> 00:58:39,320
I need you to pick something so I okay

1299
00:58:46,660 --> 00:58:43,250
so much yeah that led me to astronomy um

1300
00:58:48,220 --> 00:58:46,670
and I'm quite happy I'm keeping with it

1301
00:58:49,630 --> 00:58:48,230
because if you weren't pretty like all

1302
00:58:51,010 --> 00:58:49,640
the Astronomy cool things happening in

1303
00:58:53,290 --> 00:58:51,020
space I don't know if I'd continue with

1304
00:58:56,590 --> 00:58:53,300
it because that's just cuz of my own

1305
00:58:58,690 --> 00:58:56,600
personal interests but it's it's it is

1306
00:59:01,300 --> 00:58:58,700
in my opinion in science in general if I

1307
00:59:03,400 --> 00:59:01,310
should quit what do you play music well

1308
00:59:06,820 --> 00:59:03,410
I was I've played piano since I was four

1309
00:59:09,070 --> 00:59:06,830
and I started flute when I was in middle

1310
00:59:11,170 --> 00:59:09,080
school but by high school like around my

1311
00:59:13,420 --> 00:59:11,180
junior year I just started skipping

1312
00:59:14,620 --> 00:59:13,430
hopping from instrument to instrument to

1313
00:59:17,319 --> 00:59:14,630

whatever instrumentation the bay

1314
00:59:20,289 --> 00:59:17,329
needed for the band so I ended up on

1315
00:59:22,269 --> 00:59:20,299
tenor sax I ended up on alto sax um my

1316
00:59:23,890 --> 00:59:22,279
sister played the clarinet so I try to

1317
00:59:26,380 --> 00:59:23,900
honk a few notes my best friend was an

1318
00:59:31,059 --> 00:59:26,390
oboe player so double reed instruments

1319
00:59:35,289 --> 00:59:31,069
are the devil are you into music of the

1320
00:59:41,769 --> 00:59:35,299
spheres I'm not gonna repeat that

1321
00:59:44,289 --> 00:59:41,779
question other questions I would get a

1322
00:59:48,640 --> 00:59:44,299
couple questions from I Peter you have a

1323
00:59:51,370 --> 00:59:48,650
real question your description of

1324
00:59:54,789 --> 00:59:51,380
gravity being a distortion of space-time

1325
00:59:57,990 --> 00:59:54,799
and not a force of such I'm thinking of

1326
01:00:00,789 --> 00:59:58,000
the quest for the grand unified theory

1327
01:00:05,160 --> 01:00:00,799
still hanging out there but does this

1328
01:00:13,539 --> 01:00:05,170
kind of destroy that effort thinking of

1329
01:00:15,220 --> 01:00:13,549
gravity being something apart from okay

1330
01:00:17,829 --> 01:00:15,230
so I get a repeat the question is to

1331
01:00:19,329 --> 01:00:17,839
make sure people in line here so your

1332
01:00:21,160 --> 01:00:19,339
description subscribe gravity of course

1333
01:00:24,400 --> 01:00:21,170
in general ativy is a distortion of

1334
01:00:26,559 --> 01:00:24,410
space-time but yet there is this quest

1335
01:00:29,589 --> 01:00:26,569
for a grand unified theory and how does

1336
01:00:31,059 --> 01:00:29,599
this guy with all the other forces we

1337
01:00:34,150 --> 01:00:31,069
actually had a question about quantum

1338
01:00:35,950 --> 01:00:34,160

gravity online as well so when you were

1339
01:00:38,499 --> 01:00:35,960
discussing this people started thinking

1340
01:00:43,329 --> 01:00:38,509
you know can congrat the question online

1341
01:00:50,079 --> 01:00:43,339
was can it has gravity been it's nine

1342
01:00:52,029 --> 01:00:50,089
o'clock has been confirmed even worked

1343
01:00:54,370 --> 01:00:52,039
with the quantum mechanics I don't

1344
01:00:59,140 --> 01:00:54,380
believe there's been a bridge between

1345
01:01:01,900 --> 01:00:59,150
the two I'm not quite familiar but as to

1346
01:01:04,450 --> 01:01:01,910
whether there is a link between quantum

1347
01:01:07,779 --> 01:01:04,460
mechanics and gravity yet quantum

1348
01:01:09,130 --> 01:01:07,789
gravity has not been solved yet you

1349
01:01:15,690 --> 01:01:09,140
would have heard about it and there will

1350
01:01:20,680 --> 01:01:18,220
okay so let me explain what's happening

1351
01:01:23,860 --> 01:01:20,690
here when they redid the auditorium

1352
01:01:25,960 --> 01:01:23,870
there was an automatic shutdown that's

1353
01:01:28,810 --> 01:01:25,970
supposed to be scheduled for 10:30 every

1354
01:01:30,730 --> 01:01:28,820
night summaries in the second second

1355
01:01:32,520 --> 01:01:30,740
time it's gone off at nine o'clock while

1356
01:01:34,870 --> 01:01:32,530
we're doing the public lecture series so

1357
01:01:35,470 --> 01:01:34,880
I'm gonna ignore it I'm gonna pretend it

1358
01:01:45,070 --> 01:01:35,480
didn't happen

1359
01:01:47,980 --> 01:01:45,080
okay I don't believe there is something

1360
01:01:50,110 --> 01:01:47,990
yet discovered linking the two so I'm

1361
01:01:50,650 --> 01:01:50,120
not too familiar so I can't speak on its

1362
01:01:52,240 --> 01:01:50,660
behalf

1363
01:01:54,730 --> 01:01:52,250

okay all the way in the back what's

1364
01:01:59,560 --> 01:01:54,740
faster gravity or light which is faster

1365
01:02:05,580 --> 01:01:59,570
gravity or light well that's quite a

1366
01:02:09,810 --> 01:02:05,590
great question actually um because well

1367
01:02:12,940 --> 01:02:09,820
light moves at a pretty fast pace like I

1368
01:02:15,010 --> 01:02:12,950
would say light is faster even though we

1369
01:02:16,420 --> 01:02:15,020
have evidence of where gravity is

1370
01:02:18,640 --> 01:02:16,430
overcoming light such as black holes

1371
01:02:22,840 --> 01:02:18,650
where we can't see inside them because

1372
01:02:24,220 --> 01:02:22,850
it's so dense that light is falling in

1373
01:02:26,050 --> 01:02:24,230
faster than the speed of light therefore

1374
01:02:28,360 --> 01:02:26,060
we can't see it but I would still say

1375
01:02:31,510 --> 01:02:28,370
overall light is faster I would have to

1376
01:02:34,000 --> 01:02:31,520
correct you on that thank you with the

1377
01:02:36,460 --> 01:02:34,010
gravitational right so yeah we talked

1378
01:02:38,290 --> 01:02:36,470
about last week about the last month and

1379
01:02:40,510 --> 01:02:38,300
the month before that gravitational wave

1380
01:02:43,270 --> 01:02:40,520
astronomy that we've detected

1381
01:02:44,980 --> 01:02:43,280
gravitational waves the time delay

1382
01:02:49,810 --> 01:02:44,990
between detection in Hanford Washington

1383
01:02:52,480 --> 01:02:49,820
and in Louisiana was correspond to a

1384
01:02:54,580 --> 01:02:52,490
time delay of the speed of light so this

1385
01:02:57,220 --> 01:02:54,590
is one of the very first measures that

1386
01:03:01,360 --> 01:02:57,230
gravity waves travel at the same speed

1387
01:03:04,720 --> 01:03:01,370
of speed as light does okay we only have

1388
01:03:08,350 --> 01:03:04,730

a few measures right so but right now it

1389
01:03:10,810 --> 01:03:08,360
appears that the bias that we have that

1390
01:03:15,000 --> 01:03:10,820
gravity waves travel at gravity travels

1391
01:03:18,310 --> 01:03:17,020
so it's alright you're an undergraduate

1392
01:03:20,190 --> 01:03:18,320
you know your response to us don't know

1393
01:03:22,140 --> 01:03:20,200
everything

1394
01:03:23,400 --> 01:03:22,150
it's when you it's when you it's when

1395
01:03:31,890 --> 01:03:23,410
you get a job that you have to pretend

1396
01:03:44,220 --> 01:03:31,900
you know everything okay I have a

1397
01:03:46,140 --> 01:03:44,230
question their English people I think

1398
01:03:47,370 --> 01:03:46,150
for like like proved it through their

1399
01:03:50,789 --> 01:03:47,380
like it was an eclipse I think in the

1400
01:04:00,470 --> 01:03:50,799
nineteen yeah so he's referring to the

1401
01:04:04,349 --> 01:04:02,339
how did they measure this light

1402
01:04:07,620 --> 01:04:04,359
deflection in 1919 when they didn't have

1403
01:04:11,440 --> 01:04:07,630
computers something called photographic

1404
01:04:19,280 --> 01:04:11,450
plates which photographs what are those

1405
01:04:25,589 --> 01:04:22,020
they would use photographic plates to

1406
01:04:28,950 --> 01:04:25,599
take images of the Eclipse back in

1407
01:04:30,329 --> 01:04:28,960
nineteen and 19 1919 and actually I

1408
01:04:31,920 --> 01:04:30,339
believe they would have to sit down and

1409
01:04:35,609 --> 01:04:31,930
do the math that we had to do as well

1410
01:04:40,859 --> 01:04:35,619
right with the spherical trigonal that

1411
01:04:43,740 --> 01:04:40,869
but different we used something on but

1412
01:04:45,539 --> 01:04:43,750
mmm the image we used was on something

1413
01:04:48,539 --> 01:04:45,549

called a CCD chip a charged a couple

1414
01:04:50,010 --> 01:04:48,549
device and it's kind of it's a better

1415
01:04:52,530 --> 01:04:50,020
version of a photographic plate more

1416
01:04:53,880 --> 01:04:52,540
portable works better but that's what

1417
01:04:57,059 --> 01:04:53,890
they would use at night that's what I

1418
01:04:59,400 --> 01:04:57,069
believe they used all right so here's a

1419
01:05:01,680 --> 01:04:59,410
question from online you showed them the

1420
01:05:03,900 --> 01:05:01,690
observable universe right that you're

1421
01:05:06,240 --> 01:05:03,910
looking out you see an edge to the

1422
01:05:12,260 --> 01:05:06,250
universe so why is every point in the

1423
01:05:17,210 --> 01:05:15,560
but they why were we at the exact center

1424
01:05:19,160 --> 01:05:17,220
of that universe that was just a

1425
01:05:21,710 --> 01:05:19,170
simplistic model

1426
01:05:24,200 --> 01:05:21,720
there's nothing supposedly saying that

1427
01:05:26,620 --> 01:05:24,210
we are located at located at the center

1428
01:05:29,360 --> 01:05:26,630
of the universe I just used that shape

1429
01:05:33,170 --> 01:05:29,370
for simplicity sake when I went ahead

1430
01:05:34,460 --> 01:05:33,180
and did my own project but we there's no

1431
01:05:36,020 --> 01:05:34,470
evidence saying that we are at the

1432
01:05:38,300 --> 01:05:36,030
center of the universe we're not going

1433
01:05:41,750 --> 01:05:38,310
back to the targa jizz of a heliocentric

1434
01:05:52,580 --> 01:05:41,760
and a geocentric universe so in the back

1435
01:05:55,910 --> 01:05:52,590
there and dark energy and then it

1436
01:05:59,530 --> 01:05:55,920
covered almost the entire universe so in

1437
01:06:05,780 --> 01:05:59,540
your lecture you mentioned emptiness

1438
01:06:08,000 --> 01:06:05,790

nothing do both all right so does the

1439
01:06:10,490 --> 01:06:08,010
idea there be that dark matter and dark

1440
01:06:13,100 --> 01:06:10,500
energy comprised most of the universe

1441
01:06:14,900 --> 01:06:13,110
conflict with the idea that over the

1442
01:06:20,990 --> 01:06:14,910
presented during Olbers paradox that a

1443
01:06:24,830 --> 01:06:21,000
lot of the universe is empty mess with

1444
01:06:28,280 --> 01:06:24,840
the paradox or the solution the solution

1445
01:06:30,620 --> 01:06:28,290
to the paradox is just that the light

1446
01:06:31,190 --> 01:06:30,630
has yet to reach us and that's why it's

1447
01:06:36,470 --> 01:06:31,200
dark

1448
01:06:38,630 --> 01:06:36,480
matter you know that's what we're seeing

1449
01:06:41,360 --> 01:06:38,640
in this guy right because we can't see

1450
01:06:43,700 --> 01:06:41,370
dark energy or dark matter right if

1451
01:06:49,670 --> 01:06:43,710
that's why it's called dark it's given

1452
01:06:51,320 --> 01:06:49,680
that mysterious name um it doesn't I

1453
01:06:54,500 --> 01:06:51,330
don't believe it does yeah

1454
01:06:55,790 --> 01:06:54,510
it doesn't really interact with it the

1455
01:06:58,010 --> 01:06:55,800
light comes through one way or another

1456
01:07:00,350 --> 01:06:58,020
and it doesn't really get affected by

1457
01:07:02,870 --> 01:07:00,360
those things right matter of fact if the

1458
01:07:05,030 --> 01:07:02,880
dark matter or the dark energy changed

1459
01:07:06,740 --> 01:07:05,040
the light in a significant way it's a

1460
01:07:08,500 --> 01:07:06,750
way of detecting it and that's how of

1461
01:07:11,380 --> 01:07:08,510
course we do detect dark matter by its

1462
01:07:21,000 --> 01:07:11,390
gravitational influence on on things

1463
01:07:28,140 --> 01:07:24,120

can you relate the Milkyway size /

1464
01:07:32,840 --> 01:07:28,150
position within the universe the Milky

1465
01:07:44,110 --> 01:07:32,850
Way is 12 kiloparsecs across the

1466
01:07:44,120 --> 01:07:52,910
[Laughter]

1467
01:07:58,620 --> 01:07:55,440
well the center well the center of the

1468
01:08:01,980 --> 01:07:58,630
Milky Way is about 8.5 kiloparsecs from

1469
01:08:03,810 --> 01:08:01,990
where we are and you know we're in one

1470
01:08:05,010 --> 01:08:03,820
of the we're in one of the spiral arms

1471
01:08:12,260 --> 01:08:05,020
in Milky Way that's where we're located

1472
01:08:17,190 --> 01:08:12,270
I believe it's the the Orion we're in

1473
01:08:19,440 --> 01:08:17,200
we're inside that arm if we were so

1474
01:08:21,870 --> 01:08:19,450
we're I guess my best way of saying is

1475
01:08:24,840 --> 01:08:21,880
this we're just about if you imagine the

1476
01:08:27,330 --> 01:08:24,850
galaxy is just like a ball or a circle

1477
01:08:29,670 --> 01:08:27,340
right and here's the center where like

1478
01:08:31,830 --> 01:08:29,680
about 8.5 kiloparsecs away out of that

1479
01:08:37,610 --> 01:08:31,840
center inside one of the arms that's why

1480
01:08:54,030 --> 01:08:37,620
we are alright any other questions here

1481
01:08:59,220 --> 01:08:54,040
come on go ahead I'm silly undergrad I'm

1482
01:09:00,990 --> 01:08:59,230
still like everybody okay we have a

1483
01:09:06,720 --> 01:09:01,000
bunch of questions online but they all

1484
01:09:08,790 --> 01:09:06,730
deal with cosmological topics that they

1485
01:09:11,270 --> 01:09:08,800
go off topic a little bit too much I'll

1486
01:09:15,570 --> 01:09:11,280
I'll type in some some answers for them

1487
01:09:17,940 --> 01:09:15,580
next month January 16th third Tuesday

1488
01:09:21,750 --> 01:09:17,950

okay the James Webb Space Telescope in

1489
01:09:23,490 --> 01:09:21,760
three acts okay so third Tuesday let you

1490
01:09:25,380 --> 01:09:23,500
all have a great holiday

1491
01:09:34,349 --> 01:09:25,390
we'll see you see you next month and