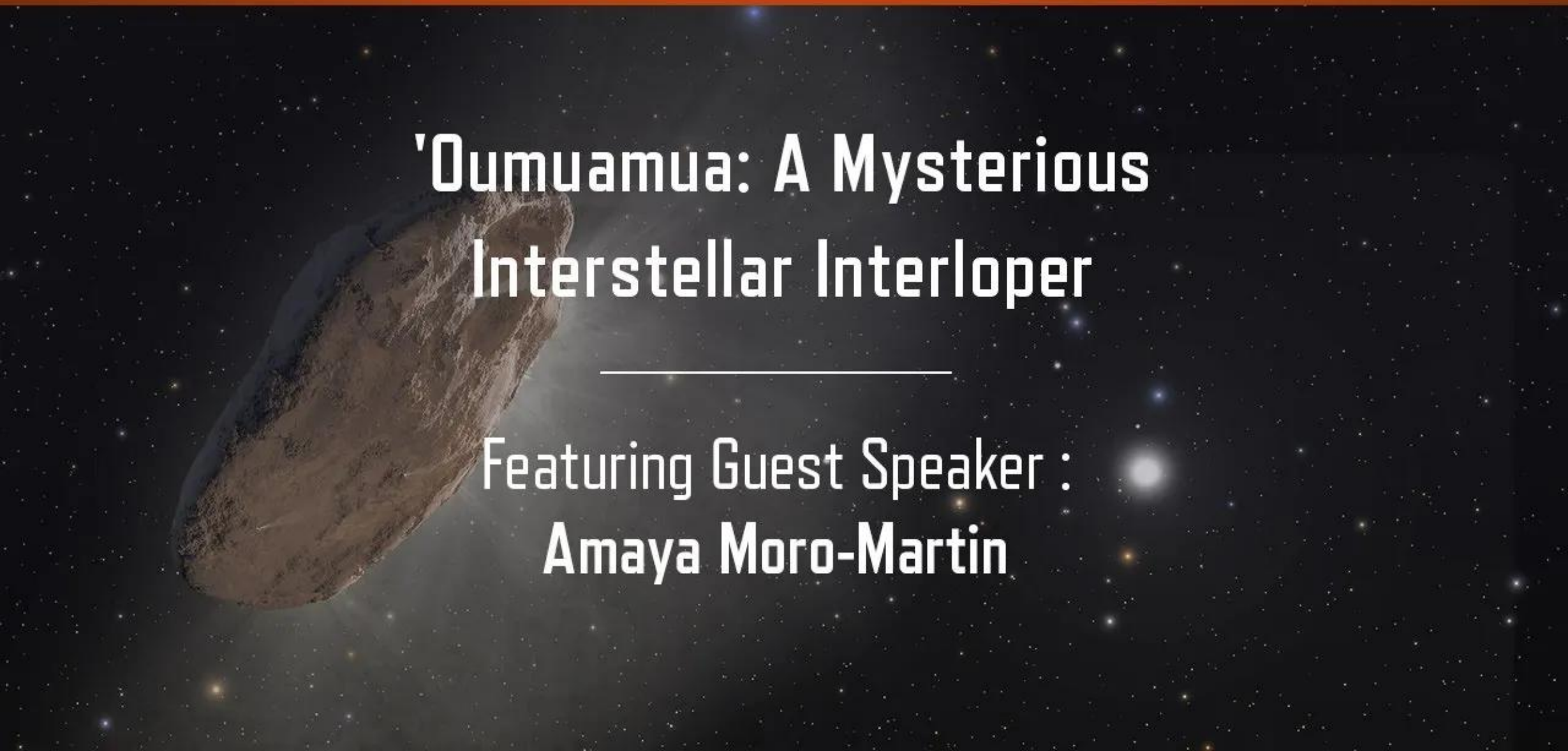
PUBLIC LECTURE SERIES



'Oumuamua: A Mysterious Interstellar Interloper

Featuring Guest Speaker :

Amaya Moro-Martin

1
00:00:03,949 --> 00:00:01,579
I'm dr. Frank summers of the Space

2
00:00:06,079 --> 00:00:03,959
Telescope Science Institute and welcome

3
00:00:06,680 --> 00:00:06,089
to the Space Telescope public lecture

4
00:00:09,950 --> 00:00:06,690
series

5
00:00:13,549 --> 00:00:09,960
our topic Oh mwah mwah a mysterious

6
00:00:15,980 --> 00:00:13,559
interstellar interloper presented by a

7
00:00:20,210 --> 00:00:15,990
my immoral Martin of the Space Telescope

8
00:00:22,580 --> 00:00:20,220
Science Institute I would like to remind

9
00:00:25,310 --> 00:00:22,590
you that the Space Telescope public

10
00:00:29,269 --> 00:00:25,320
lecture series will be online only for

11
00:00:31,279 --> 00:00:29,279
the remainder of the year 2020 and to is

12
00:00:33,500 --> 00:00:31,289
I would also like to extend a special

13
00:00:35,389 --> 00:00:33,510

thanks to our wonderful tech team who

14
00:00:35,990 --> 00:00:35,399
makes all this online experience a

15
00:00:40,819 --> 00:00:36,000
possible

16
00:00:44,299 --> 00:00:40,829
Thomas Maroof ooh and grant justice next

17
00:00:47,119 --> 00:00:44,309
month we will have on August 4th a tight

18
00:00:50,540 --> 00:00:47,129
a talk entitled armchair astrophysics

19
00:00:53,260 --> 00:00:50,550
finding physics far and wide where

20
00:00:55,369 --> 00:00:53,270
physics exists in the world that you

21
00:00:57,170 --> 00:00:55,379
experience but you may not really

22
00:01:00,170 --> 00:00:57,180
recognize it that will be presented by

23
00:01:03,380 --> 00:01:00,180
Quinn Hart in September we'll tell you

24
00:01:06,980 --> 00:01:03,390
about a brand new project that's being

25
00:01:09,080 --> 00:01:06,990
done on Hubble a huge project utilizing

26
00:01:11,390 --> 00:01:09,090
the ultraviolet capabilities of Hubble

27
00:01:14,840 --> 00:01:11,400
called Ulysses that will be presented by

28
00:01:17,240 --> 00:01:14,850
will Fisher and in October we're going

29
00:01:19,640 --> 00:01:17,250
to tell you about the Nancy Grace Roman

30
00:01:21,590 --> 00:01:19,650
space telescope this is the telescope

31
00:01:23,780 --> 00:01:21,600
that used to be known as w first the

32
00:01:27,200 --> 00:01:23,790
wide-field infrared Space Telescope but

33
00:01:29,510 --> 00:01:27,210
it was christened the Nancy Grace Roman

34
00:01:32,359 --> 00:01:29,520
space telescope now the speaker there is

35
00:01:34,969 --> 00:01:32,369
to be announced because we are having a

36
00:01:37,460 --> 00:01:34,979
conference on the Roman space telescope

37
00:01:39,410 --> 00:01:37,470
in October and the organizers of that

38
00:01:42,590 --> 00:01:39,420

conference are going to select one of

39
00:01:44,499 --> 00:01:42,600
the special visiting speakers to be the

40
00:01:46,609 --> 00:01:44,509
presenter for that public lecture series

41
00:01:54,560 --> 00:01:46,619
if you want to find out the information

42
00:01:59,959 --> 00:01:57,109
lectures and you will find this page

43
00:02:01,819 --> 00:01:59,969
here important things to know about this

44
00:02:05,450 --> 00:02:01,829
page is like over on the left side you

45
00:02:08,059 --> 00:02:05,460
can find the webcast which are both on

46
00:02:11,420 --> 00:02:08,069
our youtube playlist as well as our

47
00:02:13,309 --> 00:02:11,430
STScI webcasting site and on the right

48
00:02:15,110 --> 00:02:13,319
you can see the email

49
00:02:17,690 --> 00:02:15,120
this is where you can sign up for the

50
00:02:20,119 --> 00:02:17,700
monthly emails that tell you hey here's

51
00:02:24,170 --> 00:02:20,129
what's upcoming basically it's two maybe

52
00:02:27,610 --> 00:02:24,180
two emails a month you can of course

53
00:02:31,699 --> 00:02:27,620
also find links to our upcoming lectures

54
00:02:34,520 --> 00:02:31,709
with all of the the title and the

55
00:02:37,789 --> 00:02:34,530
speaker and the abstract when we have it

56
00:02:40,909 --> 00:02:37,799
for each of those talks there is a lot

57
00:02:43,550 --> 00:02:40,919
of detail in terms of the description as

58
00:02:47,709 --> 00:02:43,560
well as links after it's done to the

59
00:02:50,780 --> 00:02:47,719
stsci webcast and the YouTube webcast as

60
00:02:53,059 --> 00:02:50,790
I said if you want to sign up for the

61
00:02:55,789 --> 00:02:53,069
email we want the email announcements

62
00:02:58,789 --> 00:02:55,799
you can sign up at our website you can

63
00:03:01,640 --> 00:02:58,799

also subscribe to our YouTube channel

64
00:03:02,149 --> 00:03:01,650
and if you are subscriber to our YouTube

65
00:03:05,899 --> 00:03:02,159
channel

66
00:03:08,839 --> 00:03:05,909
you will get notices of our and

67
00:03:10,610 --> 00:03:08,849
reminders of our live events and finally

68
00:03:13,280 --> 00:03:10,620
if you have comments or questions you

69
00:03:17,509 --> 00:03:13,290
can send them to public lecture at STScI

70
00:03:19,159 --> 00:03:17,519
dot edu our social media channels are

71
00:03:21,409 --> 00:03:19,169
available for not just the Hubble Space

72
00:03:23,059 --> 00:03:21,419
Telescope but also the James Webb Space

73
00:03:25,280 --> 00:03:23,069
Telescope and for the Space Telescope

74
00:03:27,619 --> 00:03:25,290
Science Institute itself

75
00:03:31,339 --> 00:03:27,629
we're on Facebook we're on Twitter we're

76
00:03:33,740 --> 00:03:31,349
on YouTube or on Instagram I myself do a

77
00:03:35,960 --> 00:03:33,750
little bit on Facebook and Twitter and

78
00:03:39,710 --> 00:03:35,970
you're welcome to follow me if you would

79
00:03:43,039 --> 00:03:39,720
like okay so now the news from the

80
00:03:47,240 --> 00:03:43,049
universe for July 2020

81
00:03:51,890 --> 00:03:47,250
our first story tonight a gap in our

82
00:03:53,869 --> 00:03:51,900
knowledge of black holes so what do we

83
00:03:55,520 --> 00:03:53,879
really know about black holes well one

84
00:03:58,009 --> 00:03:55,530
of the most fundamental things about

85
00:04:02,149 --> 00:03:58,019
black holes that we know is that black

86
00:04:05,360 --> 00:04:02,159
holes have no hair this is called the

87
00:04:08,089 --> 00:04:05,370
no-hair theorem it's really just a

88
00:04:10,129 --> 00:04:08,099

statement that there are very few

89
00:04:13,279 --> 00:04:10,139
quantities you need to know about black

90
00:04:15,920 --> 00:04:13,289
holes and actually black holes are

91
00:04:19,789 --> 00:04:15,930
completely characterized by their mass

92
00:04:21,860 --> 00:04:19,799
their charge and their spin so there's

93
00:04:24,350 --> 00:04:21,870
only three things to know about a black

94
00:04:25,750 --> 00:04:24,360
hole and generally we believe black

95
00:04:28,360 --> 00:04:25,760
holes are not

96
00:04:31,210 --> 00:04:28,370
charge they have zero net charge so it's

97
00:04:32,950 --> 00:04:31,220
really mass and spin and there has

98
00:04:35,050 --> 00:04:32,960
recently been a revolution in our

99
00:04:37,960 --> 00:04:35,060
understanding of characteristics of

100
00:04:40,900 --> 00:04:37,970
black holes because of gravitational

101
00:04:44,410 --> 00:04:40,910
wave observatory z' like this this is

102
00:04:46,990 --> 00:04:44,420
the LIGO project which has a detector in

103
00:04:50,560 --> 00:04:47,000
Hanford Washington and a detector in

104
00:04:55,090 --> 00:04:50,570
Livingston Louisiana and these detectors

105
00:04:58,810 --> 00:04:55,100
detect the very minut very very very

106
00:05:02,020 --> 00:04:58,820
minut deviations in space-time created

107
00:05:04,360 --> 00:05:02,030
by gravitational waves and the LIGO

108
00:05:07,450 --> 00:05:04,370
project was the one that first detected

109
00:05:10,840 --> 00:05:07,460
black hole black hole merger they have

110
00:05:14,200 --> 00:05:10,850
since been joined by the Virgo project

111
00:05:16,660 --> 00:05:14,210
in Europe this is the detector near Pisa

112
00:05:18,820 --> 00:05:16,670
in Italy it is an international

113
00:05:22,660 --> 00:05:18,830

collaboration from France Italy the

114
00:05:25,720 --> 00:05:22,670
Netherlands Poland and Hungary and as I

115
00:05:27,760 --> 00:05:25,730
said these detectors detect them very

116
00:05:29,980 --> 00:05:27,770
fine my new flex way shion's in

117
00:05:32,650 --> 00:05:29,990
space-time when a gravitational wave

118
00:05:34,960 --> 00:05:32,660
passes through earth and this for

119
00:05:38,620 --> 00:05:34,970
example was the very first detection of

120
00:05:40,930 --> 00:05:38,630
a black hole black hole merger and from

121
00:05:44,170 --> 00:05:40,940
that we can tell various characteristics

122
00:05:45,880 --> 00:05:44,180
of the black holes so they've discovered

123
00:05:49,270 --> 00:05:45,890
a lot more since this very first

124
00:05:51,520 --> 00:05:49,280
discovery and here is a plot it's a

125
00:05:52,330 --> 00:05:51,530
little bit complex but let me just talk

126
00:05:55,960 --> 00:05:52,340
you through it okay

127
00:05:57,970 --> 00:05:55,970
so up at the top those blue things those

128
00:06:00,430 --> 00:05:57,980
are black holes that have been tected by

129
00:06:01,900 --> 00:06:00,440
gravitational waves so you can see

130
00:06:05,020 --> 00:06:01,910
they've had a lot of detections of black

131
00:06:06,940 --> 00:06:05,030
hole mergers the purple ones are black

132
00:06:09,580 --> 00:06:06,950
holes that have been detected by other

133
00:06:11,530 --> 00:06:09,590
telescopes they call them en black holes

134
00:06:14,980 --> 00:06:11,540
as they're detected by electromagnetic

135
00:06:17,950 --> 00:06:14,990
waves not gravitational waves and down

136
00:06:19,660 --> 00:06:17,960
bottom corresponding the e/m neutron

137
00:06:22,030 --> 00:06:19,670
stars the neutron stars that have been

138
00:06:25,450 --> 00:06:22,040

dictated by electromagnetic waves are in

139
00:06:28,630 --> 00:06:25,460
yellow and just a few neutron stars have

140
00:06:31,060 --> 00:06:28,640
been detected by gravitational waves so

141
00:06:33,610 --> 00:06:31,070
you can see there's a good amount of

142
00:06:39,620 --> 00:06:33,620
data that they are developing but

143
00:06:42,320 --> 00:06:39,630
recently in 2019 in octave argost for

144
00:06:43,490 --> 00:06:42,330
they discovered this highlighted one the

145
00:06:47,510 --> 00:06:43,500
one in the center that's got that

146
00:06:50,650 --> 00:06:47,520
highlight is called GW 1908 14 which

147
00:06:54,200 --> 00:06:50,660
means 2019 August 14th

148
00:06:59,029 --> 00:06:54,210
event and it was the combination of a

149
00:07:02,779 --> 00:06:59,039
2.6 solar mass object with a 23 solar

150
00:07:04,309 --> 00:07:02,789
mass object and it was unusual and well

151
00:07:06,740 --> 00:07:04,319
you might actually want to think wait

152
00:07:09,499 --> 00:07:06,750
wait how do we know these masses

153
00:07:12,439 --> 00:07:09,509
well the masses come from very studying

154
00:07:15,670 --> 00:07:12,449
those those fluctuations all right

155
00:07:19,850 --> 00:07:15,680
when two black holes merged together

156
00:07:22,610 --> 00:07:19,860
they produce gravitational waves in very

157
00:07:25,310 --> 00:07:22,620
specific patterns and these are the wave

158
00:07:29,089 --> 00:07:25,320
modes that the gravitational waves

159
00:07:31,189 --> 00:07:29,099
produced from this merger of 1908 14 and

160
00:07:33,950 --> 00:07:31,199
that you can see they're quadrupolar

161
00:07:37,790 --> 00:07:33,960
there's octupole ER there's hexa Dec you

162
00:07:39,800 --> 00:07:37,800
pull ER and then there's 32 polar why

163
00:07:41,960 --> 00:07:39,810

they couldn't just say four pole or

164
00:07:43,960 --> 00:07:41,970
eight pole or sixteen pole or 32 polar

165
00:07:48,680 --> 00:07:43,970
it would be kind of easy but you know

166
00:07:53,350 --> 00:07:48,690
yeah it wouldn't sound as a scientific

167
00:07:56,350 --> 00:07:53,360
right anyway so you can see the very

168
00:08:00,860 --> 00:07:56,360
definite predictions one can make and

169
00:08:05,149 --> 00:08:00,870
analyze the signal from a gravitational

170
00:08:09,080 --> 00:08:05,159
wave observation that allows them to

171
00:08:13,339 --> 00:08:09,090
talk about the masses here but the funky

172
00:08:17,060 --> 00:08:13,349
thing here is that 2.6 solar mass object

173
00:08:19,339 --> 00:08:17,070
all right it's larger than any neutron

174
00:08:22,129 --> 00:08:19,349
star we've ever observed but it's

175
00:08:24,469 --> 00:08:22,139
smaller than any black hole we've

176
00:08:26,300 --> 00:08:24,479
observed a matter of fact people say

177
00:08:31,129 --> 00:08:26,310
that you can't make a neutron star

178
00:08:33,980 --> 00:08:31,139
larger than 2.5 solar masses and you

179
00:08:35,930 --> 00:08:33,990
can't shouldn't really have a black hole

180
00:08:38,959 --> 00:08:35,940
less than about five solar masses so

181
00:08:41,269 --> 00:08:38,969
there's a gap a mass gap between two and

182
00:08:42,680 --> 00:08:41,279
a half and five solar masses but there

183
00:08:47,569 --> 00:08:42,690
really shouldn't be anything there and

184
00:08:50,390 --> 00:08:47,579
yet here it is we found one so there's

185
00:08:51,230 --> 00:08:50,400
the mass gap in our understanding of it

186
00:08:52,939 --> 00:08:51,240
but

187
00:08:54,739 --> 00:08:52,949
this indicates that there's sort of a

188
00:08:58,009 --> 00:08:54,749

gap in our knowledge because we have

189
00:09:01,309 --> 00:08:58,019
something in that mass gap now so the

190
00:09:03,980 --> 00:09:01,319
question is this merger was between a

191
00:09:05,210 --> 00:09:03,990
black hole and was it a neutron star or

192
00:09:08,210 --> 00:09:05,220
the largest-ever

193
00:09:11,600 --> 00:09:08,220
neutron star or was it a black hole the

194
00:09:12,859 --> 00:09:11,610
smallest ever black hole and we actually

195
00:09:15,980 --> 00:09:12,869
don't know yet

196
00:09:19,119 --> 00:09:15,990
we're still studying it it's a robust

197
00:09:21,319 --> 00:09:19,129
calculation that the mass of this object

198
00:09:23,840 --> 00:09:21,329
but they'll have to continue to study

199
00:09:25,999 --> 00:09:23,850
and get more observations from these

200
00:09:30,970 --> 00:09:26,009
gravitational wave observatory x' to

201
00:09:37,369 --> 00:09:33,559
the second story I have for you tonight

202
00:09:39,679 --> 00:09:37,379
is called comets with two tails and you

203
00:09:41,780 --> 00:09:39,689
might think that's a typo that's not a

204
00:09:44,269 --> 00:09:41,790
typo there are two tails I'm going to

205
00:09:47,689 --> 00:09:44,279
tell you about comets the first one

206
00:09:51,049 --> 00:09:47,699
involves a project called Atlas the

207
00:09:54,769 --> 00:09:51,059
asteroid terrestrial impact last alert

208
00:09:56,090 --> 00:09:54,779
system a nice reasonable acronym some of

209
00:09:57,949 --> 00:09:56,100
the acronyms astronomers come up with

210
00:10:01,400 --> 00:09:57,959
are very tortured this one's actually

211
00:10:03,650 --> 00:10:01,410
reasonable and basically what Atlas is

212
00:10:06,289 --> 00:10:03,660
looking for it's looking for objects

213
00:10:08,299 --> 00:10:06,299

that are going to kill us okay it's

214
00:10:11,480 --> 00:10:08,309
looking for potentially hazardous

215
00:10:13,549 --> 00:10:11,490
asteroids that might smash into Earth

216
00:10:16,249 --> 00:10:13,559
and cause big problems like you see in

217
00:10:18,710 --> 00:10:16,259
some of those disaster movies right and

218
00:10:21,619 --> 00:10:18,720
it has discovered 47 of those

219
00:10:24,169 --> 00:10:21,629
potentially has hazardous asteroids but

220
00:10:26,509 --> 00:10:24,179
to do so it has to scan the night sky

221
00:10:29,119 --> 00:10:26,519
really continuously over and over and

222
00:10:34,009 --> 00:10:29,129
over again and it can find other things

223
00:10:38,419 --> 00:10:34,019
so it is found 459 near-earth asteroids

224
00:10:41,359 --> 00:10:38,429
it is kept on 48 comets and it is found

225
00:10:45,169 --> 00:10:41,369
a whopping six thousand one hundred and

226
00:10:46,999 --> 00:10:45,179
seventy supernovae so monitoring the

227
00:10:50,030 --> 00:10:47,009
night sky looking for potentially

228
00:10:51,769 --> 00:10:50,040
hazardous asteroids has side benefits in

229
00:10:56,509 --> 00:10:51,779
that you get observations of all these

230
00:10:59,030 --> 00:10:56,519
other objects well it last December it

231
00:11:02,139 --> 00:10:59,040
discovered a comet and this one is

232
00:11:05,030 --> 00:11:02,149
called comet Atlas but its actual name

233
00:11:09,560 --> 00:11:05,040
nomenclature is C 2019

234
00:11:11,300 --> 00:11:09,570
why four and when folks followed up the

235
00:11:13,939 --> 00:11:11,310
discovery observations from last

236
00:11:16,850 --> 00:11:13,949
December they found that comet Atlas was

237
00:11:20,900 --> 00:11:16,860
going to get very bright and here it is

238
00:11:23,030 --> 00:11:20,910

in March of of 2020 and it was really

239
00:11:25,220 --> 00:11:23,040
bright and predictions were saying it's

240
00:11:29,600 --> 00:11:25,230
gonna get very very bright and it will

241
00:11:32,170 --> 00:11:29,610
be naked eye visible by May well that

242
00:11:34,910 --> 00:11:32,180
got the attention of astronomers who

243
00:11:36,949 --> 00:11:34,920
proposed to look at it with the Hubble

244
00:11:40,059 --> 00:11:36,959
Space Telescope and the Hubble Space

245
00:11:42,920 --> 00:11:40,069
Telescope then looked at it in April

246
00:11:45,949 --> 00:11:42,930
unfortunately this was about as bright

247
00:11:49,579 --> 00:11:45,959
as comet Atlas ever God because when

248
00:11:53,329 --> 00:11:49,589
Hubble looked at it on April 20th it had

249
00:11:55,699 --> 00:11:53,339
broken apart comets are made of ices and

250
00:11:59,389 --> 00:11:55,709
dusts and there you know Giants and

251
00:12:02,059 --> 00:11:59,399
dirty snowballs and this one obviously

252
00:12:04,240 --> 00:12:02,069
wasn't held together enough that strong

253
00:12:07,040 --> 00:12:04,250
enough that it could survive another

254
00:12:09,139 --> 00:12:07,050
passage by the Sun so here you can see

255
00:12:11,990 --> 00:12:09,149
Hubble's image of it and it had broken

256
00:12:15,860 --> 00:12:12,000
up into about 20 pieces

257
00:12:18,350 --> 00:12:15,870
all right so comet Atlas is no more that

258
00:12:22,939 --> 00:12:18,360
promise of having a naked-eye comet this

259
00:12:25,730 --> 00:12:22,949
year was unfulfilled except I have a

260
00:12:28,220 --> 00:12:25,740
second story for you and that's a comet

261
00:12:32,509 --> 00:12:28,230
that has just become naked-eye visible

262
00:12:35,470 --> 00:12:32,519
it's called comet NEOWISE its technical

263
00:12:38,960 --> 00:12:35,480

designation is C 2020 f3 and

264
00:12:41,629 --> 00:12:38,970
matter-of-fact today it was the a pot

265
00:12:45,230 --> 00:12:41,639
the Astronomy Picture of today this is a

266
00:12:49,429 --> 00:12:45,240
picture from a maroon Habeeb of the

267
00:12:50,660 --> 00:12:49,439
comet over Lebanon and you've got a lot

268
00:12:53,179 --> 00:12:50,670
of people taking pictures these days

269
00:12:56,090 --> 00:12:53,189
it's a visible like 3:00 or 4:00 in the

270
00:12:58,309 --> 00:12:56,100
morning okay and hours an hour to two

271
00:13:02,720 --> 00:12:58,319
hours before sunrise and they're able to

272
00:13:05,420 --> 00:13:02,730
get up and get get photographs of it and

273
00:13:07,579 --> 00:13:05,430
this is going to be an interesting

274
00:13:09,259 --> 00:13:07,589
comment they don't know how bright it's

275
00:13:11,840 --> 00:13:09,269
going to get

276
00:13:13,610 --> 00:13:11,850
I'm told that next week it will become

277
00:13:15,230 --> 00:13:13,620
an evening object for a bit

278
00:13:16,970 --> 00:13:15,240
that we may be able to see it in the

279
00:13:18,860 --> 00:13:16,980
evening I haven't studied this I sort of

280
00:13:21,769 --> 00:13:18,870
added this to my talk

281
00:13:23,360 --> 00:13:21,779
today when I saw it was in the a pod but

282
00:13:24,920 --> 00:13:23,370
if you want more details you got to go

283
00:13:26,900 --> 00:13:24,930
to somebody who's more into Comet

284
00:13:28,580 --> 00:13:26,910
observing than me and I'm sure there's

285
00:13:30,470 --> 00:13:28,590
lots of people out there right now with

286
00:13:32,630 --> 00:13:30,480
it and if you just want to look at the

287
00:13:35,660 --> 00:13:32,640
pretty pictures well you should go to

288
00:13:39,860 --> 00:13:35,670

the a pod site because the a pod site

289
00:13:41,930 --> 00:13:39,870
has a link to a great gallery of some

290
00:13:44,360 --> 00:13:41,940
notable images that were submitted to a

291
00:13:50,240 --> 00:13:44,370
pod that could have been chosen as the a

292
00:13:51,440 --> 00:13:50,250
pod of a comet NEOWISE and actually this

293
00:13:54,410 --> 00:13:51,450
one here right

294
00:13:58,220 --> 00:13:54,420
that's the comet over the lavender

295
00:13:59,930 --> 00:13:58,230
fields in France and I just love if I

296
00:14:02,030 --> 00:13:59,940
were choosing a pot that would have been

297
00:14:04,220 --> 00:14:02,040
my choice for today's a pod

298
00:14:07,100 --> 00:14:04,230
maybe I'm particular cause I took a

299
00:14:09,860 --> 00:14:07,110
vacation to Provence last about a little

300
00:14:11,600 --> 00:14:09,870
over a little less a year ago and we

301
00:14:13,640 --> 00:14:11,610
love seeing the lavender fields and I

302
00:14:16,490 --> 00:14:13,650
the idea of seeing a comet above the

303
00:14:18,280 --> 00:14:16,500
lavender fields not just that would be

304
00:14:19,940 --> 00:14:18,290
that would be wonderful

305
00:14:22,460 --> 00:14:19,950
unfortunately I don't think I'll be

306
00:14:25,280 --> 00:14:22,470
going to France this year but we can at

307
00:14:27,920 --> 00:14:25,290
least admire the gorgeous pictures and

308
00:14:29,990 --> 00:14:27,930
it will be interesting to see whether

309
00:14:32,540 --> 00:14:30,000
NEOWISE develops into a really bright

310
00:14:35,780 --> 00:14:32,550
naked-eye comet or it just stays at this

311
00:14:37,310 --> 00:14:35,790
fuzzy level that it's it's difficult to

312
00:14:39,680 --> 00:14:37,320
see in the night sky but you got to

313
00:14:41,780 --> 00:14:39,690

really go out and search for it so I

314
00:14:44,000 --> 00:14:41,790
encourage you if that's that's your

315
00:14:47,300 --> 00:14:44,010
favorite thing to do go out and search

316
00:14:50,750 --> 00:14:47,310
for these comments alright that's our

317
00:14:55,040 --> 00:14:50,760
news for tonight and let's go to our

318
00:15:00,440 --> 00:14:55,050
speaker our speaker is Amaya moral

319
00:15:05,690 --> 00:15:00,450
Martin and she will be talking about the

320
00:15:08,030 --> 00:15:05,700
interstellar interloper Oh mwah mwah she

321
00:15:09,980 --> 00:15:08,040
comes to us from she is here at the

322
00:15:15,740 --> 00:15:09,990
Space Telescope Science Institute an

323
00:15:18,610 --> 00:15:15,750
associate astronomer and she has she did

324
00:15:21,530 --> 00:15:18,620
her a PhD at the University of Arizona

325
00:15:23,750 --> 00:15:21,540
then she did a postdoc at Princeton

326
00:15:27,170 --> 00:15:23,760
which is where I did one of my postdocs

327
00:15:31,490 --> 00:15:27,180
and then she went to Spain to the Center

328
00:15:32,990 --> 00:15:31,500
for astrobiology before coming here and

329
00:15:35,390 --> 00:15:33,000
she's been here for 60

330
00:15:39,260 --> 00:15:35,400
she works in the mission office for the

331
00:15:42,020 --> 00:15:39,270
James Webb Space Telescope and I asked

332
00:15:43,730 --> 00:15:42,030
her what does she like to do and she has

333
00:15:46,070 --> 00:15:43,740
a wonderful hobby that she can still do

334
00:15:48,800 --> 00:15:46,080
during the coronavirus times that she

335
00:15:51,500 --> 00:15:48,810
loves to garden and she says she likes

336
00:15:54,320 --> 00:15:51,510
to promote the growth of flowers weeds

337
00:15:56,960 --> 00:15:54,330
some wild rabbits and a few children as

338
00:16:00,830 --> 00:15:56,970

well so ladies and gentlemen am i

339
00:16:03,710 --> 00:16:00,840
immoral mark hi thank you very much for

340
00:16:04,820 --> 00:16:03,720
inviting me to give this talk I'm going

341
00:16:07,190 --> 00:16:04,830
to be talking to you about

342
00:16:08,750 --> 00:16:07,200
muah-muah which is a mysterious

343
00:16:10,730 --> 00:16:08,760
interstellar interloper that you

344
00:16:15,380 --> 00:16:10,740
probably heard about because I was it

345
00:16:18,470 --> 00:16:15,390
was on the news for quite a while so in

346
00:16:20,150 --> 00:16:18,480
late October of 2017 we were surprised

347
00:16:22,280 --> 00:16:20,160
by the discovery of an object that was

348
00:16:24,260 --> 00:16:22,290
traveling the solar system so fast

349
00:16:26,570 --> 00:16:24,270
but not even the Galleon planets would

350
00:16:28,820 --> 00:16:26,580
have been able to give it such a kick it

351
00:16:30,410 --> 00:16:28,830
was crystal clear that this visitor

352
00:16:32,090 --> 00:16:30,420
wasn't going to stay because the Sun's

353
00:16:34,910 --> 00:16:32,100
gravity wouldn't be able to hold it back

354
00:16:37,820 --> 00:16:34,920
which orbit was not closer lives like

355
00:16:42,080 --> 00:16:37,830
they wanted for typical of solar system

356
00:16:43,880 --> 00:16:42,090
audience but it was open and this meant

357
00:16:46,700 --> 00:16:43,890
that the object did not originate in the

358
00:16:50,000 --> 00:16:46,710
solar system it was coming from the

359
00:16:52,790 --> 00:16:50,010
interstellar space it was the first

360
00:16:54,800 --> 00:16:52,800
interstellar object other than little

361
00:16:56,840 --> 00:16:54,810
interstellar dust particles that was

362
00:16:58,340 --> 00:16:56,850
ever detected in the solar system and

363
00:17:00,260 --> 00:16:58,350

this was very exciting

364
00:17:05,000 --> 00:17:00,270
and I'm going to show you the object now

365
00:17:07,520 --> 00:17:05,010
Saturn here it is this is the object one

366
00:17:09,860 --> 00:17:07,530
day after its discovery yes it does a

367
00:17:12,020 --> 00:17:09,870
lot you might think that at first sight

368
00:17:13,100 --> 00:17:12,030
that astronomers get easily excited but

369
00:17:16,010 --> 00:17:13,110
hang on in there

370
00:17:18,110 --> 00:17:16,020
this object was named mwah mwah that in

371
00:17:20,360 --> 00:17:18,120
Hawaiian means something like distant

372
00:17:23,240 --> 00:17:20,370
messenger referring to the fact that it

373
00:17:25,220 --> 00:17:23,250
was a first interstellar Pistor what was

374
00:17:27,680 --> 00:17:25,230
its message well I would think that its

375
00:17:30,740 --> 00:17:27,690
message was that the universe is full of

376
00:17:32,600 --> 00:17:30,750
surprises I was particularly surprised

377
00:17:34,970 --> 00:17:32,610
about this discovery because 10 years

378
00:17:36,530 --> 00:17:34,980
prior when very few people were paying

379
00:17:39,320 --> 00:17:36,540
attention to the topic of interstellar

380
00:17:41,600 --> 00:17:39,330
interlopers I let a study to try to

381
00:17:44,210 --> 00:17:41,610
understand why we had not detected any

382
00:17:46,070 --> 00:17:44,220
at that point even though such an object

383
00:17:48,529 --> 00:17:46,080
will have been easily

384
00:17:50,690 --> 00:17:48,539
because of its the extreme trajectory

385
00:17:53,090 --> 00:17:50,700
right any parabola rather than an

386
00:17:55,130 --> 00:17:53,100
ellipse we go to the conclusion in this

387
00:17:57,680 --> 00:17:55,140
study but the number of interstellar

388
00:17:59,360 --> 00:17:57,690

obvious per volume office space was so

389
00:18:02,120 --> 00:17:59,370
low that the detection of one of these

390
00:18:05,210 --> 00:18:02,130
extrasolar comments will require surveys

391
00:18:07,460 --> 00:18:05,220
that will go very deep and are able to

392
00:18:09,350 --> 00:18:07,470
detect very faint objects and that was a

393
00:18:11,330 --> 00:18:09,360
capability that we didn't have any time

394
00:18:15,769 --> 00:18:11,340
at the time we still don't have it now

395
00:18:19,730 --> 00:18:15,779
but eventually we would have it and this

396
00:18:22,460 --> 00:18:19,740
is the Vera Rubin Observatory which is

397
00:18:24,889 --> 00:18:22,470
was formerly known as the large synoptic

398
00:18:28,100 --> 00:18:24,899
survey telescope it will start

399
00:18:30,259 --> 00:18:28,110
operations in 2022 you can see how huge

400
00:18:32,570 --> 00:18:30,269
it is by looking how small the person is

401
00:18:34,519 --> 00:18:32,580
to the lower right and also there is an

402
00:18:34,940 --> 00:18:34,529
18 wheeler in there so this thing is

403
00:18:37,549 --> 00:18:34,950
huge

404
00:18:40,820 --> 00:18:37,559
so another study we argue that the

405
00:18:42,200 --> 00:18:40,830
survey capacity of this telescope might

406
00:18:44,389 --> 00:18:42,210
be able to detect interstellar

407
00:18:47,149 --> 00:18:44,399
interlopers or conclusion ten years

408
00:18:49,250 --> 00:18:47,159
before the discovery from 1 MOA was that

409
00:18:51,590 --> 00:18:49,260
this type of interstellar interlopers

410
00:18:53,960 --> 00:18:51,600
would be detected eventually but we

411
00:18:55,820 --> 00:18:53,970
needed to be patient and wait so when

412
00:18:57,769 --> 00:18:55,830
the first interstellar interloper was

413
00:19:00,139 --> 00:18:57,779

detected with Sun stars which is this

414
00:19:04,129 --> 00:19:00,149
little survey telescope so here to the

415
00:19:06,710 --> 00:19:04,139
left we were very surprised very and

416
00:19:08,750 --> 00:19:06,720
shortly after its discovery we realized

417
00:19:11,539 --> 00:19:08,760
that we had gotten very lucky because of

418
00:19:15,830 --> 00:19:11,549
1 MOA was actually quite as small about

419
00:19:19,610 --> 00:19:15,840
100 meters in size so this is a blow out

420
00:19:21,470 --> 00:19:19,620
of the orbit and again the only reason

421
00:19:23,060 --> 00:19:21,480
that we were able to detect it with

422
00:19:24,980 --> 00:19:23,070
pan-starrs is because it happened to

423
00:19:28,909 --> 00:19:24,990
pass very close to the earth as you can

424
00:19:30,590 --> 00:19:28,919
see here and this was one we actually

425
00:19:32,690 --> 00:19:30,600
detected when it was on its way out of

426
00:19:36,980 --> 00:19:32,700
the solar system we never saw it coming

427
00:19:39,350 --> 00:19:36,990
in and it passed within the orbit of the

428
00:19:41,690 --> 00:19:39,360
earth on october 14 that happens to be

429
00:19:43,940 --> 00:19:41,700
my birthday so try to be bad as a

430
00:19:46,399 --> 00:19:43,950
birthday surprise it passed for the

431
00:19:48,440 --> 00:19:46,409
distance of approximately point 16 au

432
00:19:49,970 --> 00:19:48,450
which is about 60 times the distance

433
00:19:53,269 --> 00:19:49,980
from the earth to the moon so it was

434
00:19:55,669 --> 00:19:53,279
very close and by that Halloween it was

435
00:19:57,889 --> 00:19:55,679
already on the orbit of Mars a colleague

436
00:19:58,800 --> 00:19:57,899
of mine refers to a more massive ad from

437
00:20:02,130 --> 00:19:58,810
hell well

438
00:20:04,470 --> 00:20:02,140

is some fast but so we were surprised by

439
00:20:06,450 --> 00:20:04,480
its discovery but we didn't know at the

440
00:20:10,890 --> 00:20:06,460
time was the dissonance of surprise will

441
00:20:12,090 --> 00:20:10,900
turn into utter bewilderment so because

442
00:20:14,520 --> 00:20:12,100
it was coming from the interstellar

443
00:20:17,220 --> 00:20:14,530
medium where it is only a few degrees

444
00:20:19,140 --> 00:20:17,230
above absolute zero well one would have

445
00:20:21,930 --> 00:20:19,150
thought that one more would be icy like

446
00:20:24,840 --> 00:20:21,940
a solar system comment the one so here

447
00:20:26,490 --> 00:20:24,850
is our beloved comet Holly as commit to

448
00:20:29,160 --> 00:20:26,500
get close to the Sun part of the ice

449
00:20:32,040 --> 00:20:29,170
near the surface sublimates and this gas

450
00:20:34,350 --> 00:20:32,050
lost into his face drags along some dust

451
00:20:37,110 --> 00:20:34,360
particles from the Comets surface this

452
00:20:39,450 --> 00:20:37,120
creates a coma a gas tail and dust tail

453
00:20:41,640 --> 00:20:39,460
like the one so he so careful from it

454
00:20:44,510 --> 00:20:41,650
honey because we thought one more would

455
00:20:47,280 --> 00:20:44,520
be icy astronomers search formulas comet

456
00:20:50,280 --> 00:20:47,290
daggers and Estelle said nothing was

457
00:20:52,860 --> 00:20:50,290
found if a memo was in thanks I see then

458
00:20:54,480 --> 00:20:52,870
it must be rocky like an asteroid but

459
00:20:56,820 --> 00:20:54,490
soon they realized it didn't look like a

460
00:20:59,310 --> 00:20:56,830
normal a spirit either based on its

461
00:21:01,320 --> 00:20:59,320
brightness and its distance and making

462
00:21:03,660 --> 00:21:01,330
some assumptions about how efficiently

463
00:21:06,210 --> 00:21:03,670

it reflects light astronomers estimated

464
00:21:08,490 --> 00:21:06,220
that Mamula was only about 100 meters in

465
00:21:11,670 --> 00:21:08,500
size it smaller than most known

466
00:21:14,160 --> 00:21:11,680
asteroids they also observed that it's

467
00:21:16,770 --> 00:21:14,170
brightness fluctuated every eight hours

468
00:21:19,380 --> 00:21:16,780
very sharply at times to come in 10

469
00:21:21,420 --> 00:21:19,390
times brighter in this video you see

470
00:21:23,670 --> 00:21:21,430
these fluctuations some brightness

471
00:21:25,920 --> 00:21:23,680
variation is expected because a small

472
00:21:28,500 --> 00:21:25,930
rocky objects are like rotating lumpy

473
00:21:29,910 --> 00:21:28,510
potatoes at times more of its area will

474
00:21:31,710 --> 00:21:29,920
be facing us and then they will look

475
00:21:33,750 --> 00:21:31,720
brighter and then one less area is

476
00:21:35,670 --> 00:21:33,760
facing us they look fainter but

477
00:21:37,950 --> 00:21:35,680
generally this bright net radiation is

478
00:21:40,370 --> 00:21:37,960
quite a small but for the momo it was

479
00:21:44,070 --> 00:21:40,380
very drastic about the factor of time

480
00:21:46,890 --> 00:21:44,080
this meant that maja she was very

481
00:21:49,050 --> 00:21:46,900
unusual it was hit a very elongated like

482
00:21:54,240 --> 00:21:49,060
the images so here you see here to the

483
00:21:57,390 --> 00:21:54,250
left or very flat so it was you know

484
00:21:59,880 --> 00:21:57,400
either like a penne pasta or a pancake

485
00:22:03,750 --> 00:21:59,890
but when I saw food other people saw

486
00:22:07,620 --> 00:22:03,760
this and now he's going to get

487
00:22:08,730 --> 00:22:07,630
interesting so upon closer inspection of

488
00:22:11,190 --> 00:22:08,740

mo mo

489
00:22:12,300 --> 00:22:11,200
it was discovered that the object was

490
00:22:15,270 --> 00:22:12,310
being accelerated

491
00:22:16,800 --> 00:22:15,280
like a rocket this is non gravitational

492
00:22:19,290 --> 00:22:16,810
acceleration makes a noticeable

493
00:22:20,820 --> 00:22:19,300
difference in the trajectory I'm going

494
00:22:23,580 --> 00:22:20,830
to show you the trajectory for more and

495
00:22:25,980 --> 00:22:23,590
more here the red is what you would

496
00:22:27,540 --> 00:22:25,990
expect if there were no excess

497
00:22:29,760 --> 00:22:27,550
acceleration and the only acceleration

498
00:22:31,890 --> 00:22:29,770
was was that created by the Sun and the

499
00:22:33,840 --> 00:22:31,900
planets gravity while the blue is what

500
00:22:36,360 --> 00:22:33,850
was actually observed you see that there

501
00:22:39,500 --> 00:22:36,370
is a big difference so something that is

502
00:22:43,530 --> 00:22:39,510
not gravity is accelerating the object

503
00:22:45,660 --> 00:22:43,540
now this yet like force is typical in

504
00:22:47,490 --> 00:22:45,670
comets and is caused by the mass loss

505
00:22:49,950 --> 00:22:47,500
that happens on the day size of the

506
00:22:52,140 --> 00:22:49,960
nucleus where they icy sublimating

507
00:22:55,740 --> 00:22:52,150
because that creates a jet reaction

508
00:22:58,050 --> 00:22:55,750
force and this affects the orbit but as

509
00:23:00,450 --> 00:22:58,060
I pointed out before more is not did not

510
00:23:03,240 --> 00:23:00,460
saw evidence of having any cos or or

511
00:23:04,740 --> 00:23:03,250
dad's been lost detecting the gas is

512
00:23:07,350 --> 00:23:04,750
striking but detecting the dust would

513
00:23:09,240 --> 00:23:07,360

have been easier and there was none so

514
00:23:11,160 --> 00:23:09,250
we don't have any evidence that the non

515
00:23:13,560 --> 00:23:11,170
gravitational acceleration observing mom

516
00:23:16,890 --> 00:23:13,570
was trajectory was caused by mass loss

517
00:23:19,710 --> 00:23:16,900
but then what could be causing it so

518
00:23:21,210 --> 00:23:19,720
there was the suggestion but this extra

519
00:23:23,670 --> 00:23:21,220
acceleration could be due to the

520
00:23:25,530 --> 00:23:23,680
radiation pressure from the Sun a force

521
00:23:27,390 --> 00:23:25,540
that is created by the comet by the

522
00:23:29,760 --> 00:23:27,400
collective kicks of solar photons

523
00:23:32,610 --> 00:23:29,770
hitting on the surface or the often

524
00:23:34,290 --> 00:23:32,620
object but if radiation pressure is very

525
00:23:36,900 --> 00:23:34,300
weak these are just photons hitting a

526
00:23:39,600 --> 00:23:36,910
surface right so for it to cause the

527
00:23:41,550 --> 00:23:39,610
acceleration that was observed the

528
00:23:43,860 --> 00:23:41,560
object would have to have a lot of area

529
00:23:46,740 --> 00:23:43,870
and very little mass so it could be push

530
00:23:49,110 --> 00:23:46,750
easily like a cell it was suggested that

531
00:23:51,930 --> 00:23:49,120
more and more I was like a membrane

532
00:23:54,600 --> 00:23:51,940
structure of a very thin material

533
00:23:55,950 --> 00:23:54,610
less than a millimeter thick and because

534
00:23:58,950 --> 00:23:55,960
it is quite unlikely that such a

535
00:24:00,870 --> 00:23:58,960
membrane could be produced naturally the

536
00:24:03,950 --> 00:24:00,880
proposal was that it was a loud cell

537
00:24:06,900 --> 00:24:03,960
from an extraterrestrial civilization I

538
00:24:10,080 --> 00:24:06,910

thought about this and proposed at

539
00:24:12,060 --> 00:24:10,090
another way an object with very little

540
00:24:15,000 --> 00:24:12,070
masks and half a lot of surface area

541
00:24:17,370 --> 00:24:15,010
they were the solar photons can import

542
00:24:19,680 --> 00:24:17,380
the little kicks is if the audience had

543
00:24:23,210 --> 00:24:19,690
a fractal structure like a snowflake and

544
00:24:26,040 --> 00:24:23,220
this could also explain the mossad shape

545
00:24:26,310 --> 00:24:26,050
it will make it very unusual because it

546
00:24:29,549 --> 00:24:26,320
will

547
00:24:32,820 --> 00:24:29,559
play that mwah mwah ha an extraordinary

548
00:24:35,180 --> 00:24:32,830
low density about 100,000 times lower

549
00:24:37,889 --> 00:24:35,190
than water damn water and lower

550
00:24:39,990 --> 00:24:37,899
congressman our deal which is the lowest

551
00:24:44,009 --> 00:24:40,000
density synthetically produced material

552
00:24:46,950 --> 00:24:44,019
known to give you an idea how light our

553
00:24:49,680 --> 00:24:46,960
graphene our gel is you can see this

554
00:24:52,259 --> 00:24:49,690
picture here of a piece being held by

555
00:24:55,889 --> 00:24:52,269
flour so we're talking about a very very

556
00:24:58,169 --> 00:24:55,899
very light material so I proposed a

557
00:25:00,840 --> 00:24:58,179
fractal structure because fractals are

558
00:25:03,029 --> 00:25:00,850
found in many forms of nature and are

559
00:25:05,460 --> 00:25:03,039
thought to arise naturally because that

560
00:25:08,430 --> 00:25:05,470
formation processes involve an element

561
00:25:10,049 --> 00:25:08,440
of stochasticity of randomness like

562
00:25:12,299 --> 00:25:10,059
particle collisions in a portal

563
00:25:17,190 --> 00:25:12,309

protoplanetary disk or particles in a

564
00:25:19,080 --> 00:25:17,200
solution and this is what you see here

565
00:25:21,299 --> 00:25:19,090
is an interplanetary particle and

566
00:25:24,289 --> 00:25:21,309
interplanetary dust particle collected

567
00:25:27,600 --> 00:25:24,299
in the space is about 10 microns in size

568
00:25:30,600 --> 00:25:27,610
its core has a fractal structure and

569
00:25:33,240 --> 00:25:30,610
it's formation involves random particle

570
00:25:35,730 --> 00:25:33,250
collisions so what I propose as an

571
00:25:38,310 --> 00:25:35,740
alternative to the lights and hypothesis

572
00:25:40,740 --> 00:25:38,320
was that indeed Wawa was being pushed by

573
00:25:43,590 --> 00:25:40,750
radiation pressure but that it wasn't a

574
00:25:46,320 --> 00:25:43,600
membrane that it was something like this

575
00:25:48,360 --> 00:25:46,330
interstellar interplanetary dust

576
00:25:51,960 --> 00:25:48,370
particle but much larger on a much

577
00:25:55,139 --> 00:25:51,970
larger size but how could such an object

578
00:25:59,039 --> 00:25:55,149
form because we know how dust particles

579
00:26:03,600 --> 00:25:59,049
form but we don't know how to form such

580
00:26:06,509 --> 00:26:03,610
large organ objects so now let me step

581
00:26:08,610 --> 00:26:06,519
back a bit and let me tell you in order

582
00:26:11,249 --> 00:26:08,620
to explain how such an object could form

583
00:26:14,070 --> 00:26:11,259
let me explain you how stars are born

584
00:26:17,249 --> 00:26:14,080
how planets are born so stars are born

585
00:26:19,710 --> 00:26:17,259
in molecular clouds of gas and dust in

586
00:26:21,810 --> 00:26:19,720
some region of the cloud the density is

587
00:26:23,940 --> 00:26:21,820
higher and this makes the reunion

588
00:26:26,070 --> 00:26:23,950

contract under the effect of its own

589
00:26:28,139 --> 00:26:26,080
gravity and eventually this forms a ball

590
00:26:30,629 --> 00:26:28,149
of gas that is much denser and hotter

591
00:26:33,539 --> 00:26:30,639
than the rest of the cloud and we call

592
00:26:37,950 --> 00:26:33,549
these very dense and hot video if a

593
00:26:39,930 --> 00:26:37,960
producer around this protester there is

594
00:26:42,180 --> 00:26:39,940
this envelope of gas and dust

595
00:26:44,999 --> 00:26:42,190
is rotating and contracting at the same

596
00:26:46,529 --> 00:26:45,009
time and this makes it flatten into an

597
00:26:49,499 --> 00:26:46,539
pissed because of conservation of

598
00:26:53,460 --> 00:26:49,509
angular momentum here you can see in

599
00:26:56,700 --> 00:26:53,470
this image a two disks and in Orion seen

600
00:27:01,110 --> 00:26:56,710
in silhouette and with a protostar in

601
00:27:03,810 --> 00:27:01,120
their center so the dust particles that

602
00:27:06,899 --> 00:27:03,820
are in these disks remember these disks

603
00:27:09,810 --> 00:27:06,909
have Gaston does business particles are

604
00:27:11,369 --> 00:27:09,820
very small about 21 microns in size and

605
00:27:13,619 --> 00:27:11,379
they collide with each other frequently

606
00:27:16,049 --> 00:27:13,629
in some of these collisions the best

607
00:27:18,509 --> 00:27:16,059
particles stick to each other and form

608
00:27:20,220 --> 00:27:18,519
aggregates like the interstellar dust

609
00:27:22,529 --> 00:27:20,230
particles shown here that you can see

610
00:27:25,830 --> 00:27:22,539
that this compost is really an aggregate

611
00:27:27,930 --> 00:27:25,840
of mini small particles these aggregates

612
00:27:29,789 --> 00:27:27,940
collide with each other and grow into

613
00:27:32,310 --> 00:27:29,799

pea bombs or the mentally coalesce into

614
00:27:33,930 --> 00:27:32,320
larger bodies known as planetesimals the

615
00:27:38,669 --> 00:27:33,940
candidate of the size of comets and

616
00:27:41,009 --> 00:27:38,679
asteroids and then eventually under some

617
00:27:43,799 --> 00:27:41,019
circumstances this can lead to the

618
00:27:46,139 --> 00:27:43,809
formation of planets shares the solid

619
00:27:48,090 --> 00:27:46,149
course and then the alien planet has the

620
00:27:50,249 --> 00:27:48,100
most massive course they started

621
00:27:51,869 --> 00:27:50,259
tracking the gas in the disc forming

622
00:27:54,299 --> 00:27:51,879
gaseous envelope forming their

623
00:27:58,100 --> 00:27:54,309
atmosphere like the two planets that you

624
00:28:00,779 --> 00:27:58,110
can see here forming in these discs so

625
00:28:03,450 --> 00:28:00,789
they are numerical simulations that they

626
00:28:05,999 --> 00:28:03,460
study these collisional growths of vast

627
00:28:07,740 --> 00:28:06,009
particles into larger bodies and these

628
00:28:11,070 --> 00:28:07,750
simulations predict that if the dust

629
00:28:13,230 --> 00:28:11,080
particles are icy and are very small the

630
00:28:15,869 --> 00:28:13,240
accurate is that will form will have

631
00:28:18,119 --> 00:28:15,879
less and less density as they grow

632
00:28:20,070 --> 00:28:18,129
because they are colliding they are

633
00:28:22,259 --> 00:28:20,080
creating these fractal structures I'm

634
00:28:24,509 --> 00:28:22,269
going when they collide there is some

635
00:28:26,279 --> 00:28:24,519
compression that happens but you

636
00:28:27,930 --> 00:28:26,289
actually on the corn when you collide

637
00:28:31,499 --> 00:28:27,940
particles you actually are creating more

638
00:28:34,470 --> 00:28:31,509

vacuum because of this fractal structure

639
00:28:36,659 --> 00:28:34,480
so and this is what is represented here

640
00:28:40,730 --> 00:28:36,669
as the size in this graph has this

641
00:28:45,180 --> 00:28:40,740
particle grows in size its density drops

642
00:28:47,460 --> 00:28:45,190
so this cosmic dust bunnies then we can

643
00:28:50,070 --> 00:28:47,470
call them like that like the model so

644
00:28:51,720 --> 00:28:50,080
here could be pushed by radiation

645
00:28:52,960 --> 00:28:51,730
pressure because they will have enough

646
00:28:56,140 --> 00:28:52,970
area and

647
00:28:57,940 --> 00:28:56,150
wait very little so the idea that I

648
00:29:00,100 --> 00:28:57,950
proposed was that Mulla Mulla could be

649
00:29:01,779 --> 00:29:00,110
one of those intermediate early products

650
00:29:03,880 --> 00:29:01,789
of the planet formation process that

651
00:29:07,570 --> 00:29:03,890
arises naturally from the collisional

652
00:29:09,669 --> 00:29:07,580
growth of icy dust grains and if it were

653
00:29:12,730 --> 00:29:09,679
the case that muah-muah was a cosmic

654
00:29:15,070 --> 00:29:12,740
dust bunny for me the outer part of the

655
00:29:16,990 --> 00:29:15,080
protoplanetary disk of another star it

656
00:29:18,909 --> 00:29:17,000
would be extraordinarily exciting

657
00:29:20,710 --> 00:29:18,919
because very little is known about this

658
00:29:23,760 --> 00:29:20,720
intermediate early products of granite

659
00:29:26,529 --> 00:29:23,770
formation and imagine is very difficult

660
00:29:28,120 --> 00:29:26,539
we haven't been able to observe this in

661
00:29:29,919 --> 00:29:28,130
the distance imagine thinking about the

662
00:29:33,360 --> 00:29:29,929
possibility that one of these fragments

663
00:29:36,669 --> 00:29:33,370

is coming to us with just mind blowing

664
00:29:40,090 --> 00:29:36,679
so there has been other proposals for

665
00:29:42,430 --> 00:29:40,100
mamas nature for example it was

666
00:29:45,909 --> 00:29:42,440
suggested that such an ultra porous

667
00:29:47,860 --> 00:29:45,919
object with no gas could be a desiccated

668
00:29:50,020 --> 00:29:47,870
fragment resulted from the

669
00:29:52,659 --> 00:29:50,030
disintegration of an ordinary extrasolar

670
00:29:55,270 --> 00:29:52,669
comment under some conditions and this

671
00:29:57,520 --> 00:29:55,280
ties very well with the news that we

672
00:29:58,990 --> 00:29:57,530
just got from Frank where we were

673
00:30:00,520 --> 00:29:59,000
looking at this object that we were

674
00:30:03,159 --> 00:30:00,530
expecting that it would be very bright

675
00:30:05,919 --> 00:30:03,169
and it is integrated well maybe you mama

676
00:30:08,560 --> 00:30:05,929
is one of these fragments of an

677
00:30:13,899 --> 00:30:08,570
extrasolar comment that got too close to

678
00:30:17,560 --> 00:30:13,909
the Sun and disintegrated others have

679
00:30:20,200 --> 00:30:17,570
suggested that mama is made of molecular

680
00:30:23,140 --> 00:30:20,210
hydrogen eyes and that it could be a

681
00:30:25,029 --> 00:30:23,150
cosmic hydrogen iceberg that originated

682
00:30:27,490 --> 00:30:25,039
in the coldest regions of a molecular

683
00:30:30,010 --> 00:30:27,500
cloud with the sublimation of the

684
00:30:32,350 --> 00:30:30,020
molecular hydrogen being responsible for

685
00:30:35,440 --> 00:30:32,360
this rocket like propulsion that we

686
00:30:37,240 --> 00:30:35,450
observe the issue with this proposal is

687
00:30:40,149 --> 00:30:37,250
that it cannot account for the lack of

688
00:30:41,919 --> 00:30:40,159

dust as a molecular hydrogen that will

689
00:30:43,510 --> 00:30:41,929
sublimate that we need to sublimate

690
00:30:46,450 --> 00:30:43,520
because it will account for the push

691
00:30:47,919 --> 00:30:46,460
would drag alone dust particles and the

692
00:30:50,500 --> 00:30:47,929
dust particles would have been observed

693
00:30:52,180 --> 00:30:50,510
but they were not observed and it also

694
00:30:55,210 --> 00:30:52,190
has been argued that molecular hydrogen

695
00:30:57,279 --> 00:30:55,220
is so volatile as such a body could not

696
00:31:01,530 --> 00:30:57,289
have been formed in a molecular cloud or

697
00:31:05,800 --> 00:31:01,540
could have survived interstellar travel

698
00:31:08,380 --> 00:31:05,810
another proposal formula is that

699
00:31:11,620 --> 00:31:08,390
muah-muah is the result of a tidal

700
00:31:14,320 --> 00:31:11,630
disruption event under this scenario a

701
00:31:16,180 --> 00:31:14,330
comet-like object would have come too

702
00:31:18,430 --> 00:31:16,190
close to his fairness turn and the tidal

703
00:31:21,340 --> 00:31:18,440
forces of the star would have tear it

704
00:31:23,590 --> 00:31:21,350
apart into a located fragments but could

705
00:31:26,220 --> 00:31:23,600
be ejected into interstellar space and

706
00:31:30,160 --> 00:31:26,230
more would be one of those you know

707
00:31:32,410 --> 00:31:30,170
fragments not having tear apart so as

708
00:31:34,240 --> 00:31:32,420
you can see we just don't know we have

709
00:31:36,070 --> 00:31:34,250
all these possibilities but we just

710
00:31:40,540 --> 00:31:36,080
don't know and unfortunately a moonwalk

711
00:31:42,550 --> 00:31:40,550
and no longer be observed so we don't we

712
00:31:46,570 --> 00:31:42,560
cannot get more observations to test any

713
00:31:48,790 --> 00:31:46,580

of these hypotheses so do we expect all

714
00:31:50,620 --> 00:31:48,800
interested or interlopers to be pleased

715
00:31:54,010 --> 00:31:50,630
we're on this fascinating

716
00:31:55,690 --> 00:31:54,020
a second interstellar interloper was

717
00:31:57,030 --> 00:31:55,700
detected two years after the discovery

718
00:32:01,360 --> 00:31:57,040
of four mwah mwah

719
00:32:04,480 --> 00:32:01,370
it came even faster than mama so it was

720
00:32:06,820 --> 00:32:04,490
clearly interstellar and because it's

721
00:32:09,040 --> 00:32:06,830
velocity it was so high and because he

722
00:32:12,670 --> 00:32:09,050
didn't get as close to the Sun as sumo

723
00:32:14,800 --> 00:32:12,680
its trajectory was not been as much so

724
00:32:17,860 --> 00:32:14,810
you can see it here the trajectory of

725
00:32:20,320 --> 00:32:17,870
this second interstellar interloper is

726
00:32:25,540 --> 00:32:20,330
in yellow and more mas trajectories in

727
00:32:27,970 --> 00:32:25,550
in red so this is a close-up of the of

728
00:32:29,920 --> 00:32:27,980
the orbit it didn't get as close to the

729
00:32:33,220 --> 00:32:29,930
earth as ooh mama but it was easier to

730
00:32:36,460 --> 00:32:33,230
see because it had gas and dust emission

731
00:32:38,650 --> 00:32:36,470
so in had a coma it has a tail

732
00:32:41,020 --> 00:32:38,660
so finally who had detected that first

733
00:32:42,250 --> 00:32:41,030
interstellar comet because of more and

734
00:32:44,410 --> 00:32:42,260
more was the first interstellar

735
00:32:47,190 --> 00:32:44,420
interloper but it was on a common and

736
00:32:50,500 --> 00:32:47,200
this was the first interstellar comment

737
00:32:52,900 --> 00:32:50,510
so it was actively detected I mean find

738
00:32:55,120 --> 00:32:52,910

this very curious it was actually

739
00:32:58,030 --> 00:32:55,130
detected by an optical engineering a

740
00:33:02,200 --> 00:32:58,040
called Bora shots using a small

741
00:33:04,420 --> 00:33:02,210
telescope that he built himself so this

742
00:33:07,390 --> 00:33:04,430
is not any amateur astronomer he was an

743
00:33:09,490 --> 00:33:07,400
optical engineer right so this faint

744
00:33:11,770 --> 00:33:09,500
blob these are the discovery limits this

745
00:33:14,050 --> 00:33:11,780
flame blob moving across the image is

746
00:33:18,550 --> 00:33:14,060
worrisome I'm in the comment not the

747
00:33:21,880 --> 00:33:18,560
another person right and this is the

748
00:33:25,330 --> 00:33:21,890
also Borissov but seen with Hubble

749
00:33:27,400 --> 00:33:25,340
it is fussy because of all the gas one

750
00:33:30,610 --> 00:33:27,410
that's been lost due to its eyes hidden

751
00:33:33,220 --> 00:33:30,620
up and it looks like a normal solar

752
00:33:34,750 --> 00:33:33,230
system comet is that that is moving way

753
00:33:38,140 --> 00:33:34,760
too fast to be coming from the solar

754
00:33:40,900 --> 00:33:38,150
system it is estimated that it's nucleus

755
00:33:43,900 --> 00:33:40,910
is between two to five times larger than

756
00:33:46,900 --> 00:33:43,910
one more about that is about 200 to 500

757
00:33:49,840 --> 00:33:46,910
meters in size but it didn't show any

758
00:33:52,120 --> 00:33:49,850
evidence of being that elongated so it's

759
00:33:56,890 --> 00:33:52,130
not that we think that this obvious had

760
00:34:00,550 --> 00:33:56,900
such a drastic elongated or flattened

761
00:34:02,200 --> 00:34:00,560
shape its trajectory did show a non

762
00:34:03,910 --> 00:34:02,210
gravitational acceleration but this

763
00:34:05,590 --> 00:34:03,920

could be accounted for because of all

764
00:34:08,140 --> 00:34:05,600
the gas and dust that is really lost

765
00:34:10,870 --> 00:34:08,150
from the part of the nucleus that faces

766
00:34:12,910 --> 00:34:10,880
the Sun so its trajectory there were no

767
00:34:14,500 --> 00:34:12,920
surprises in the trajectory so there was

768
00:34:16,780 --> 00:34:14,510
nothing to worry about this object

769
00:34:19,540 --> 00:34:16,790
instead that it was very rich in carbon

770
00:34:22,930 --> 00:34:19,550
monoxide richer than almost all solar

771
00:34:25,270 --> 00:34:22,940
system comments and because carbon

772
00:34:27,220 --> 00:34:25,280
monoxide is so easy to vaporize this

773
00:34:30,250 --> 00:34:27,230
probably means that this extrasolar

774
00:34:32,890 --> 00:34:30,260
comment originated from the outermost

775
00:34:34,660 --> 00:34:32,900
region of its host planetary system

776
00:34:36,670 --> 00:34:34,670
where it's very cold and the carbon

777
00:34:38,890 --> 00:34:36,680
monoxide can stay a nice form

778
00:34:41,260 --> 00:34:38,900
it was probably ejected into the

779
00:34:43,150 --> 00:34:41,270
interstellar space because he passed too

780
00:34:48,010 --> 00:34:43,160
close to a large planet in that

781
00:34:50,200 --> 00:34:48,020
planetary system so this is indeed a

782
00:34:53,110 --> 00:34:50,210
planetesimal coming from the outer

783
00:34:57,370 --> 00:34:53,120
region of a planet of a protoplanetary

784
00:34:59,650 --> 00:34:57,380
disc around other star so how are these

785
00:35:01,930 --> 00:34:59,660
objects ejected this is how we think

786
00:35:04,180 --> 00:35:01,940
they are ejected into interstellar space

787
00:35:06,010 --> 00:35:04,190
this is the John this I'm going to show

788
00:35:08,710 --> 00:35:06,020

you now a model of the young solar

789
00:35:11,920 --> 00:35:08,720
system the red yellow and blue

790
00:35:15,700 --> 00:35:11,930
and yet the red yellow blue and purple

791
00:35:17,980 --> 00:35:15,710
lines and the purple ellipses right

792
00:35:20,320 --> 00:35:17,990
although all those polar ellipses are

793
00:35:24,040 --> 00:35:20,330
the orbits of Jupiter Saturn Neptune and

794
00:35:26,320 --> 00:35:24,050
Uranus respectively the green dots that

795
00:35:27,300 --> 00:35:26,330
are moving here very happily are

796
00:35:28,800 --> 00:35:27,310
planetesimal

797
00:35:31,110 --> 00:35:28,810
that are located beyond the orbit of

798
00:35:34,020 --> 00:35:31,120
Neptune and as you will see in this

799
00:35:35,370 --> 00:35:34,030
video at about 880 million years from

800
00:35:36,780 --> 00:35:35,380
the start of the simulation there is a

801
00:35:38,580 --> 00:35:36,790
gravitational instability that

802
00:35:40,560 --> 00:35:38,590
rearranges the orbits of the giant

803
00:35:42,620 --> 00:35:40,570
planets and ejects most of the

804
00:35:46,440 --> 00:35:42,630
planetesimals into interstellar space

805
00:35:49,650 --> 00:35:46,450
you see is going to happen right now

806
00:35:52,800 --> 00:35:49,660
so you see most of the planetesimals

807
00:35:54,360 --> 00:35:52,810
hold on and of course this is just a

808
00:35:56,580 --> 00:35:54,370
simulation but there is indeed evidence

809
00:35:59,280 --> 00:35:56,590
that the asteroid and the Kuiper belts

810
00:36:01,230 --> 00:35:59,290
in the solar system today contain only a

811
00:36:03,210 --> 00:36:01,240
very small fraction of the objects that

812
00:36:05,420 --> 00:36:03,220
were there initially so there is

813
00:36:09,000 --> 00:36:05,430

evidence has such gravitational

814
00:36:11,640 --> 00:36:09,010
ejections of core and that they were

815
00:36:14,990 --> 00:36:11,650
salted in the clearing of most of the

816
00:36:17,160 --> 00:36:15,000
planetesimals in the early solar system

817
00:36:19,290 --> 00:36:17,170
numerical simulations like this one

818
00:36:21,540 --> 00:36:19,300
showed that these clearing processes are

819
00:36:24,120 --> 00:36:21,550
very common under a wide range of

820
00:36:26,040 --> 00:36:24,130
planetary architectures so it's not only

821
00:36:28,110 --> 00:36:26,050
for the solar system but we expect this

822
00:36:31,140 --> 00:36:28,120
to be common around many planetary

823
00:36:32,790 --> 00:36:31,150
systems and this ejections event would

824
00:36:35,130 --> 00:36:32,800
most likely take place when the

825
00:36:37,380 --> 00:36:35,140
planetary systems are very young and the

826
00:36:39,270 --> 00:36:37,390
planetary orbits are still rearranging

827
00:36:45,360 --> 00:36:39,280
themselves trying to look for that is

828
00:36:47,580 --> 00:36:45,370
community so many of these objects would

829
00:36:49,860 --> 00:36:47,590
have experienced very little alteration

830
00:36:52,860 --> 00:36:49,870
cinders since their formation because

831
00:36:55,620 --> 00:36:52,870
they are ejected the planetesimals are

832
00:36:57,900 --> 00:36:55,630
ejected early in the solar in the planet

833
00:36:59,910 --> 00:36:57,910
in their planetary system history and

834
00:37:02,910 --> 00:36:59,920
once they are ejected into interstellar

835
00:37:05,520 --> 00:37:02,920
space this interstellar planetesimals

836
00:37:08,400 --> 00:37:05,530
would drift for millions and hundreds of

837
00:37:10,740 --> 00:37:08,410
millions of years in the deep freeze of

838
00:37:13,170 --> 00:37:10,750

the interstellar medium where they will

839
00:37:15,060 --> 00:37:13,180
remain an altar so there will be like

840
00:37:18,390 --> 00:37:15,070
time capsules from their planetary

841
00:37:19,740 --> 00:37:18,400
systems most distant past eventually one

842
00:37:21,990 --> 00:37:19,750
of these interstellar planetesimals

843
00:37:24,000 --> 00:37:22,000
would cross paths with the solar system

844
00:37:26,580 --> 00:37:24,010
becoming an interstellar interloper

845
00:37:28,560 --> 00:37:26,590
like a Borissov and this will

846
00:37:30,270 --> 00:37:28,570
offer us this is offering us the

847
00:37:32,400 --> 00:37:30,280
opportunity to glimpse the building

848
00:37:35,940 --> 00:37:32,410
blocks of planets around other stars and

849
00:37:38,040 --> 00:37:35,950
this is why they are so fascinating the

850
00:37:39,420 --> 00:37:38,050
frequency of these encounters depend on

851
00:37:41,190 --> 00:37:39,430
the number of interstellar current

852
00:37:43,650 --> 00:37:41,200
ASIMO's per unit volume of

853
00:37:45,120 --> 00:37:43,660
things if you know that is then the

854
00:37:47,310 --> 00:37:45,130
number density of interstellar

855
00:37:48,750 --> 00:37:47,320
planetesimals is very hard hi

856
00:37:51,660 --> 00:37:48,760
then peace encounters will be very

857
00:37:53,880 --> 00:37:51,670
frequent so we can actually actually

858
00:37:55,470 --> 00:37:53,890
calculate or have a rough estimate of

859
00:37:57,270 --> 00:37:55,480
this number of the number of

860
00:38:00,030 --> 00:37:57,280
interstellar Contessa moles per unit

861
00:38:02,609 --> 00:38:00,040
volume of his face based on the observed

862
00:38:06,359 --> 00:38:02,619
numbers of stars per unit volume of

863
00:38:07,890 --> 00:38:06,369

festers for off of his face and making

864
00:38:10,859 --> 00:38:07,900
an estimate of how many planetesimals

865
00:38:11,940 --> 00:38:10,869
each star would and yet of course there

866
00:38:13,500 --> 00:38:11,950
are many uncertainties in this

867
00:38:14,880 --> 00:38:13,510
calculation and we have to do a lot of

868
00:38:17,819 --> 00:38:14,890
hand waving which is something that

869
00:38:20,010 --> 00:38:17,829
astronomers do very well but a generous

870
00:38:21,089 --> 00:38:20,020
upper limit would imply that within the

871
00:38:22,980 --> 00:38:21,099
orbit of Neptune

872
00:38:25,079 --> 00:38:22,990
there would be about a hundred to a

873
00:38:27,900 --> 00:38:25,089
thousand interstellar objects and

874
00:38:29,880 --> 00:38:27,910
anything at any given time and this is

875
00:38:32,400 --> 00:38:29,890
where we encounter another of more and

876
00:38:35,490 --> 00:38:32,410
more mysteries if you didn't have enough

877
00:38:38,760 --> 00:38:35,500
and because we know it passed within

878
00:38:41,609 --> 00:38:38,770
point for a you of the earth we also

879
00:38:43,940 --> 00:38:41,619
know that the pan-starrs survey had only

880
00:38:46,410 --> 00:38:43,950
been in operation for a few years and

881
00:38:48,750 --> 00:38:46,420
from these from these two facts you can

882
00:38:50,940 --> 00:38:48,760
estimate that they're about 10,000 meter

883
00:38:53,550 --> 00:38:50,950
stellar objects like more within the

884
00:38:56,280 --> 00:38:53,560
orbit of Neptune that number is between

885
00:38:58,500 --> 00:38:56,290
ten and a hundred times larger than what

886
00:39:00,329 --> 00:38:58,510
we estimated before from the ejection of

887
00:39:03,240 --> 00:39:00,339
colitas image from extrasolar planetary

888
00:39:05,520 --> 00:39:03,250

systems and the key question that we

889
00:39:08,640 --> 00:39:05,530
haven't been able to solve yet is or

890
00:39:10,440 --> 00:39:08,650
where is all that leader coming from so

891
00:39:12,030 --> 00:39:10,450
if you have a small children in the

892
00:39:13,520 --> 00:39:12,040
house you probably know what I'm talking

893
00:39:18,089 --> 00:39:13,530
about

894
00:39:20,880 --> 00:39:18,099
so one interesting idea that has been

895
00:39:23,520 --> 00:39:20,890
proposed is that since we have so many

896
00:39:26,730 --> 00:39:23,530
planetesimals drifting around around him

897
00:39:28,859 --> 00:39:26,740
you know in interstellar space the same

898
00:39:31,260 --> 00:39:28,869
way that muah-muah on Boris off crossed

899
00:39:33,089 --> 00:39:31,270
paths with our solar system this

900
00:39:35,400 --> 00:39:33,099
interstellar planetesimals would also

901
00:39:38,940 --> 00:39:35,410
enter the environments where stars and

902
00:39:41,069 --> 00:39:38,950
planet formation are taking place like

903
00:39:43,880 --> 00:39:41,079
this giant molecule or clouds or or

904
00:39:46,920 --> 00:39:43,890
these protostellar disks and these

905
00:39:48,839 --> 00:39:46,930
environments will be very dense and this

906
00:39:51,720 --> 00:39:48,849
incoming of this might get trapped

907
00:39:53,280 --> 00:39:51,730
instead of just fly by like happen what

908
00:39:54,910 --> 00:39:53,290
happened to a more more more ease of in

909
00:39:59,200 --> 00:39:54,920
our solar system we just

910
00:40:02,250 --> 00:39:59,210
fly by the the gravity of the Sun on the

911
00:40:04,569 --> 00:40:02,260
planets wasn't able to hold it but in in

912
00:40:06,730 --> 00:40:04,579
environments like a molecular cloud and

913
00:40:09,880 --> 00:40:06,740

protostellar discs that are much more

914
00:40:11,710 --> 00:40:09,890
massive and ants then trap in multi it

915
00:40:13,900 --> 00:40:11,720
might take place and this truck

916
00:40:16,569 --> 00:40:13,910
planetesimals could have sizes that are

917
00:40:18,730 --> 00:40:16,579
large enough to rapidly grow into larger

918
00:40:19,930 --> 00:40:18,740
bodies we had a direct accretion of the

919
00:40:21,730 --> 00:40:19,940
Sun centimeter

920
00:40:24,130 --> 00:40:21,740
sighs that's greatest in the disk and

921
00:40:27,099 --> 00:40:24,140
they could act as seeds for planet

922
00:40:30,539 --> 00:40:27,109
formation so it's kind of poetic right

923
00:40:33,099 --> 00:40:30,549
you have these romance these remnants

924
00:40:35,079 --> 00:40:33,109
young planetary systems being thrown

925
00:40:37,299 --> 00:40:35,089
into space being clear out and these

926
00:40:39,549 --> 00:40:37,309
same remnants could become seeds of

927
00:40:42,640 --> 00:40:39,559
planet formation in other planetary

928
00:40:44,410 --> 00:40:42,650
systems that are being born and I'm

929
00:40:46,690 --> 00:40:44,420
talking about seeds a planet for me so

930
00:40:48,370 --> 00:40:46,700
how about seeds for life good life heat

931
00:40:52,450 --> 00:40:48,380
you're right in an interstellar planet

932
00:40:54,730 --> 00:40:52,460
decimal and land on the planet well

933
00:40:56,910 --> 00:40:54,740
there are organisms that are remarkably

934
00:41:00,069 --> 00:40:56,920
resilient to the hazards of outer space

935
00:41:02,170 --> 00:41:00,079
meat for example they tardy correct this

936
00:41:04,630 --> 00:41:02,180
is one of the most resilient organisms

937
00:41:06,730 --> 00:41:04,640
that are known it seems that it has like

938
00:41:10,809 --> 00:41:06,740

an integrated extinction the hair space

939
00:41:12,970 --> 00:41:10,819
right so some organisms if buried below

940
00:41:15,460 --> 00:41:12,980
the surface of the object where they are

941
00:41:17,589 --> 00:41:15,470
shield from the damaging cosmic rays and

942
00:41:20,200 --> 00:41:17,599
UV radiation that can really do bad

943
00:41:21,910 --> 00:41:20,210
things to the DNA if they are buried

944
00:41:24,039 --> 00:41:21,920
under the surface under a meter or so

945
00:41:26,499 --> 00:41:24,049
they might be able to survive in

946
00:41:28,259 --> 00:41:26,509
interstellar space for millions of years

947
00:41:31,059 --> 00:41:28,269
in a dormant state

948
00:41:33,519 --> 00:41:31,069
but then interstellar objects have very

949
00:41:35,769 --> 00:41:33,529
high velocities so most of them will

950
00:41:38,079 --> 00:41:35,779
burn up in the atmosphere as they get to

951
00:41:40,720 --> 00:41:38,089
a planet right so there is little hope

952
00:41:43,480 --> 00:41:40,730
they will actually land and survive but

953
00:41:47,170 --> 00:41:43,490
they are interstellar objects that may

954
00:41:48,849 --> 00:41:47,180
be able to land on the surface and for

955
00:41:51,160 --> 00:41:48,859
this they would be subjected to very

956
00:41:54,609 --> 00:41:51,170
high temperatures and pressures created

957
00:41:56,470 --> 00:41:54,619
by the impact shock but actually they

958
00:41:59,349 --> 00:41:56,480
are bacteria that are able to survive

959
00:42:01,779 --> 00:41:59,359
under those conditions so the transfer

960
00:42:04,329 --> 00:42:01,789
of life through interstellar space even

961
00:42:06,190 --> 00:42:04,339
though it seems quite unlikely is an

962
00:42:07,059 --> 00:42:06,200
interesting possibility that at this

963
00:42:08,620 --> 00:42:07,069

point

964
00:42:14,739 --> 00:42:08,630
the knowledge that we have today we

965
00:42:18,699 --> 00:42:14,749
cannot roll out and I will accrue end up

966
00:42:21,699 --> 00:42:18,709
with this is light and it shows the

967
00:42:27,130 --> 00:42:21,709
tapestries showing commit hardly and

968
00:42:30,130 --> 00:42:27,140
dates back to 1066 1066 so this is

969
00:42:32,709 --> 00:42:30,140
almost almost a thousand years ago and

970
00:42:34,719 --> 00:42:32,719
its analysis very well where we are at

971
00:42:38,769 --> 00:42:34,729
with respect to our understanding of

972
00:42:40,749 --> 00:42:38,779
more and more and it's pure wonder but

973
00:42:42,699 --> 00:42:40,759
remember that the second interstellar

974
00:42:45,150 --> 00:42:42,709
object was detected with a homemade

975
00:42:47,829 --> 00:42:45,160
telescope so probably more of these

976
00:42:50,559 --> 00:42:47,839
objects have been detected before but

977
00:42:52,420 --> 00:42:50,569
not perceived and the same happened to

978
00:42:53,799 --> 00:42:52,430
Pluto on the capable audience they were

979
00:42:56,589 --> 00:42:53,809
detected decades before they will

980
00:42:59,469 --> 00:42:56,599
actually identify so now that we know

981
00:43:01,569 --> 00:42:59,479
interstellar obvious exists they will

982
00:43:03,430 --> 00:43:01,579
probably be easier to identify and this

983
00:43:05,469 --> 00:43:03,440
will allow us to characterize the

984
00:43:08,229 --> 00:43:05,479
interest electron decimal population and

985
00:43:13,719 --> 00:43:08,239
shed light on its origin and maybe souls

986
00:43:17,859 --> 00:43:13,729
all those more mysteries and so I would

987
00:43:21,099 --> 00:43:17,869
like to finish there Thank You Maya that

988
00:43:22,299 --> 00:43:21,109

was wonderful and uh unfortunately I

989
00:43:25,959 --> 00:43:22,309
could say you answered a lot of

990
00:43:28,799 --> 00:43:25,969
questions but you also brought up almost

991
00:43:32,109 --> 00:43:28,809
as many questions as you answered there

992
00:43:33,609 --> 00:43:32,119
one of the things that struck me so I

993
00:43:35,380 --> 00:43:33,619
always get the honor of asking the first

994
00:43:39,609 --> 00:43:35,390
question was that you showed the

995
00:43:41,709 --> 00:43:39,619
simulation that where Neptune kicks out

996
00:43:45,339 --> 00:43:41,719
all the objects in the Kuiper belt

997
00:43:48,249 --> 00:43:45,349
region now when I did my undergraduate

998
00:43:50,199 --> 00:43:48,259
work way back when it was sort of

999
00:43:52,689 --> 00:43:50,209
implied that Jupiter being the most

1000
00:43:54,729 --> 00:43:52,699
massive of the giant planets was

1001
00:43:57,299 --> 00:43:54,739
responsible for say the Oort cloud

1002
00:44:01,059 --> 00:43:57,309
kicking out was that something I

1003
00:44:03,039 --> 00:44:01,069
misheard or was it's just this outer

1004
00:44:06,789 --> 00:44:03,049
stuff that's mostly affected by Neptune

1005
00:44:09,519 --> 00:44:06,799
right not it's mostly affected by us

1006
00:44:13,299 --> 00:44:09,529
with Jupiter ok so there is a resonance

1007
00:44:15,279 --> 00:44:13,309
with you Peter that swaps swaps through

1008
00:44:17,109 --> 00:44:15,289
the Kuiper belt and it is that resonance

1009
00:44:20,259 --> 00:44:17,119
is stability created by that's personal

1010
00:44:20,800 --> 00:44:20,269
that clears the object so it's it's the

1011
00:44:23,110 --> 00:44:20,810
inter

1012
00:44:24,850 --> 00:44:23,120
play between Jupiter and Saturn is the

1013
00:44:27,190 --> 00:44:24,860

resonance that is sweeping so Neptune

1014
00:44:28,930 --> 00:44:27,200
doesn't play such a big role so it's

1015
00:44:32,140 --> 00:44:28,940
mainly is there and Saturn that are

1016
00:44:34,300 --> 00:44:32,150
driving Neptune has that you know but

1017
00:44:36,880 --> 00:44:34,310
Neptune is swapping orbits with Uranus

1018
00:44:38,650 --> 00:44:36,890
which we've known about as well right it

1019
00:44:40,270 --> 00:44:38,660
looks like makes it look like Neptune's

1020
00:44:43,780 --> 00:44:40,280
the one that that's doing the encounters

1021
00:44:47,560 --> 00:44:43,790
in the kicking okay well the resonance

1022
00:44:52,090 --> 00:44:47,570
effects affects the orbit of Neptune and

1023
00:44:56,770 --> 00:44:52,100
rain and rain right so now we're gonna

1024
00:44:58,810 --> 00:44:56,780
bring in grant justice folks that have

1025
00:45:00,460 --> 00:44:58,820
been watching on YouTube have been

1026
00:45:02,050 --> 00:45:00,470
entering a lot of questions in the chat

1027
00:45:05,560 --> 00:45:02,060
I've only had a chance to check it every

1028
00:45:06,970 --> 00:45:05,570
now and then he's got a lot of questions

1029
00:45:11,290 --> 00:45:06,980
to choose from there's a lot today

1030
00:45:12,940 --> 00:45:11,300
yeah so grant pull some questions sure I

1031
00:45:16,330 --> 00:45:12,950
think I'm gonna limit it down to

1032
00:45:22,450 --> 00:45:16,340
probably three based on the length of

1033
00:45:24,790 --> 00:45:22,460
the expected replies one of the

1034
00:45:26,890 --> 00:45:24,800
questions I got that was repeated in

1035
00:45:29,950 --> 00:45:26,900
many different forms was can you talk a

1036
00:45:34,060 --> 00:45:29,960
little bit more about how a Mulla Mulla

1037
00:45:37,660 --> 00:45:34,070
got captured by the solar system oh you

1038
00:45:43,270 --> 00:45:37,670

did not get captured so when you see

1039
00:45:46,570 --> 00:45:43,280
they I can show you let's see um here

1040
00:45:48,120 --> 00:45:46,580
I'm going to kinda share the string

1041
00:45:56,320 --> 00:45:48,130
again

1042
00:45:56,330 --> 00:46:02,349
[Music]

1043
00:46:10,849 --> 00:46:07,370
okay so can you can you see it yes yes

1044
00:46:14,900 --> 00:46:10,859
we can see it okay so here's a mwah mwah

1045
00:46:18,680 --> 00:46:14,910
in the right trajectory and it's not

1046
00:46:23,180 --> 00:46:18,690
catcher is coming in is its orbit is me

1047
00:46:25,730 --> 00:46:23,190
invented by the gravitational I'm seeing

1048
00:46:26,809 --> 00:46:25,740
your presenter view not your oh you're

1049
00:46:36,079 --> 00:46:26,819
seeing the presenter view

1050
00:46:37,749 --> 00:46:36,089
okay so let's let's try work perfectly

1051
00:46:41,180 --> 00:46:37,759
before but you know these online

1052
00:46:44,480 --> 00:46:41,190
presentations always have a questioner

1053
00:46:50,089 --> 00:46:44,490
to the bear in the chat that was asking

1054
00:46:51,049 --> 00:46:50,099
if we were alive yes so let me let me

1055
00:46:54,109 --> 00:46:51,059
say it with words

1056
00:46:59,180 --> 00:46:54,119
so when Omaha came into the solar system

1057
00:47:01,819 --> 00:46:59,190
they the trajectory got bent but it left

1058
00:47:06,079 --> 00:47:01,829
the solar system as fast as if as it

1059
00:47:09,259 --> 00:47:06,089
came by right so by you know 15 months

1060
00:47:12,079 --> 00:47:09,269
after it closed it got closed today to

1061
00:47:14,150 --> 00:47:12,089
the Sun and after we discovered it it

1062
00:47:15,380 --> 00:47:14,160
was already by little bit of Saturn so

1063
00:47:17,720 --> 00:47:15,390

it never got captured

1064
00:47:20,710 --> 00:47:17,730
we Soviets did not get capturing the

1065
00:47:23,690 --> 00:47:20,720
solar system they are lots forever

1066
00:47:26,059 --> 00:47:23,700
the interstellar medium as you throw a

1067
00:47:27,499 --> 00:47:26,069
bat out of hell it just came screaming

1068
00:47:30,319 --> 00:47:27,509
through the solar system and went out

1069
00:47:31,519 --> 00:47:30,329
and called this you just correct this is

1070
00:47:38,509 --> 00:47:31,529
a hyperbolic orbit

1071
00:47:40,279 --> 00:47:38,519
orbit it's not a right an ellipse it is

1072
00:47:43,999 --> 00:47:40,289
an ellipse it will be coming back all

1073
00:47:47,329 --> 00:47:44,009
comments come back you know at most they

1074
00:47:51,170 --> 00:47:47,339
are like all right but but this was

1075
00:47:53,289 --> 00:47:51,180
clearly very open lips well I've been a

1076
00:47:56,529 --> 00:47:53,299
very open hyperbolic orbit right

1077
00:47:59,450 --> 00:47:56,539
polygons which are open but this was and

1078
00:48:01,849 --> 00:47:59,460
I mean it's trajectory did get bent

1079
00:48:04,970 --> 00:48:01,859
because he plus it passed really close

1080
00:48:07,160 --> 00:48:04,980
today to the Sun but it was it wasn't

1081
00:48:09,130 --> 00:48:07,170
rough so this object is not going to

1082
00:48:11,930 --> 00:48:09,140
come back like a periodic comet

1083
00:48:13,729 --> 00:48:11,940
unfortunately so less of a capture and

1084
00:48:15,109 --> 00:48:13,739
more like a slingshot orbit

1085
00:48:20,599 --> 00:48:15,119
yes

1086
00:48:23,450 --> 00:48:20,609
right exactly okay and is there anything

1087
00:48:26,239 --> 00:48:23,460
observed that has a similar makeup to a

1088
00:48:29,870 --> 00:48:26,249

mullah that's in our solar system or are

1089
00:48:32,779 --> 00:48:29,880
you absolute no absolutely not

1090
00:48:35,630 --> 00:48:32,789
we we there is nothing in the solar

1091
00:48:38,239 --> 00:48:35,640
system that has the properties that we

1092
00:48:39,859 --> 00:48:38,249
have observed from one form one one I

1093
00:48:41,630 --> 00:48:39,869
mean you can look at the colors and the

1094
00:48:44,450 --> 00:48:41,640
colors don't look that different from

1095
00:48:47,479 --> 00:48:44,460
other objects in the solar system but

1096
00:48:49,579 --> 00:48:47,489
clearly with the acceleration that we

1097
00:48:52,729 --> 00:48:49,589
found in the trajectory there is much

1098
00:48:54,979 --> 00:48:52,739
more there than the colors so so no

1099
00:48:58,400 --> 00:48:54,989
nothing in the solar system has those

1100
00:49:00,200 --> 00:48:58,410
characteristics so if they something

1101
00:49:01,789 --> 00:49:00,210
like that did exist it would have been

1102
00:49:06,470 --> 00:49:01,799
in the early solar system and probably

1103
00:49:08,900 --> 00:49:06,480
got kicked out is that right yes yes yes

1104
00:49:11,479 --> 00:49:08,910
exactly so one of the theories right

1105
00:49:14,029 --> 00:49:11,489
that we put forward was that maybe it

1106
00:49:16,880 --> 00:49:14,039
was like a very primordial planet

1107
00:49:19,069 --> 00:49:16,890
decimal platform and and it was having

1108
00:49:21,289 --> 00:49:19,079
take out right right but everything

1109
00:49:22,910 --> 00:49:21,299
would with those same low density

1110
00:49:24,829 --> 00:49:22,920
primordial planet as must have formed

1111
00:49:28,190 --> 00:49:24,839
possibly or formed in our solar system

1112
00:49:30,259 --> 00:49:28,200
they could have form but it's not I mean

1113
00:49:32,089 --> 00:49:30,269

we just don't know right the question

1114
00:49:35,900 --> 00:49:32,099
they planetesimals that we observe now

1115
00:49:37,819 --> 00:49:35,910
are these closest to the primarily

1116
00:49:39,200 --> 00:49:37,829
apparent decimals or comments right

1117
00:49:41,479 --> 00:49:39,210
committee are wonderful because they've

1118
00:49:43,249 --> 00:49:41,489
been they were ejected early in the

1119
00:49:45,829 --> 00:49:43,259
solar system history so they have not

1120
00:49:48,109 --> 00:49:45,839
been altered that much but comets have a

1121
00:49:49,849 --> 00:49:48,119
density of about point 1 grams per

1122
00:49:52,249 --> 00:49:49,859
second that's ten times less than water

1123
00:49:56,269 --> 00:49:52,259
and we are talking about a not yet that

1124
00:49:59,989 --> 00:49:56,279
if radiation pressure is responsible I

1125
00:50:03,400 --> 00:49:59,999
mean if they if if they know

1126
00:50:06,109 --> 00:50:03,410
gravitational acceleration observe is

1127
00:50:07,460 --> 00:50:06,119
cannot be accounted has to be accounted

1128
00:50:09,259 --> 00:50:07,470
by radiation pressure then this thing

1129
00:50:10,849 --> 00:50:09,269
will have to have a very low density and

1130
00:50:13,880 --> 00:50:10,859
it's like nothing like in the solar

1131
00:50:17,329 --> 00:50:13,890
system right and even even if it's not

1132
00:50:20,329 --> 00:50:17,339
even if you think that there is actually

1133
00:50:21,920 --> 00:50:20,339
mass loss and the problem is that for

1134
00:50:24,049 --> 00:50:21,930
some reason we couldn't observe it and

1135
00:50:25,759 --> 00:50:24,059
which we are still don't understand why

1136
00:50:27,829 --> 00:50:25,769
that would have been the case but even

1137
00:50:28,320 --> 00:50:27,839
assuming that and assuming that they was

1138
00:50:31,470 --> 00:50:28,330

no

1139
00:50:34,080 --> 00:50:31,480
object its shape is very drastic it's

1140
00:50:35,760 --> 00:50:34,090
very uh negated or like a pancake and

1141
00:50:39,330 --> 00:50:35,770
nothing in the solar system that we've

1142
00:50:40,200 --> 00:50:39,340
observed has such a jurisdiction so he

1143
00:50:44,160 --> 00:50:40,210
was very unique

1144
00:50:48,210 --> 00:50:44,170
I think that's why it brought so much

1145
00:50:51,240 --> 00:50:48,220
attention from everyone so another one

1146
00:50:54,330 --> 00:50:51,250
here do each action velocities match up

1147
00:50:56,250 --> 00:50:54,340
to observed values or did it pick up or

1148
00:50:58,170 --> 00:50:56,260
lose feet on the way we alluded earlier

1149
00:51:02,570 --> 00:50:58,180
to it being kind of a slingshot orbit

1150
00:51:06,990 --> 00:51:02,580
but was that actually the case with more

1151
00:51:10,440 --> 00:51:07,000
it would for for boy shock that is mass

1152
00:51:12,030 --> 00:51:10,450
loss that would have started when it was

1153
00:51:16,140 --> 00:51:12,040
approaching right so the velocity we

1154
00:51:20,090 --> 00:51:16,150
will will be affected right and for for

1155
00:51:23,340 --> 00:51:20,100
for the case of day of a mom or if

1156
00:51:25,890 --> 00:51:23,350
something was you know pushing it as

1157
00:51:30,570 --> 00:51:25,900
well so by all means the velocity would

1158
00:51:32,700 --> 00:51:30,580
change right so the velocities are they

1159
00:51:35,640 --> 00:51:32,710
like tens tens of kilometers per second

1160
00:51:36,900 --> 00:51:35,650
yeah yeah right so for more it was

1161
00:51:38,580 --> 00:51:36,910
traveling at the velocity with respect

1162
00:51:40,890 --> 00:51:38,590
to the sum of about twenty six

1163
00:51:43,320 --> 00:51:40,900

kilometers per second for Boris off I

1164
00:51:45,780 --> 00:51:43,330
think it was more in the 40s something

1165
00:51:49,230 --> 00:51:45,790
like that so it was Borissov was coming

1166
00:51:51,870 --> 00:51:49,240
much faster so really the time to travel

1167
00:51:54,480 --> 00:51:51,880
between solar systems would be on order

1168
00:51:58,500 --> 00:51:54,490
of tens of thousands of years when

1169
00:51:59,970 --> 00:51:58,510
you're traveling at speeds like that if

1170
00:52:02,370 --> 00:51:59,980
you were direct going directly from one

1171
00:52:04,710 --> 00:52:02,380
solar system to another you can travel a

1172
00:52:08,460 --> 00:52:04,720
few parsecs and you know ten thousand

1173
00:52:13,170 --> 00:52:08,470
years right yeah but how fast does it do

1174
00:52:16,410 --> 00:52:13,180
the Kessel run Frank and we don't know

1175
00:52:19,320 --> 00:52:16,420
because ya know I was going to say that

1176
00:52:21,780 --> 00:52:19,330
we don't know where if you try to trace

1177
00:52:23,760 --> 00:52:21,790
the trajectory back in time you may

1178
00:52:25,290 --> 00:52:23,770
arguable you know maybe you can trace

1179
00:52:27,330 --> 00:52:25,300
where it came from

1180
00:52:29,280 --> 00:52:27,340
right we actually can't it's very

1181
00:52:31,080 --> 00:52:29,290
difficult to do that because there are a

1182
00:52:35,490 --> 00:52:31,090
lot of gravitational perturbations and

1183
00:52:38,640 --> 00:52:35,500
also the stars are you know they start

1184
00:52:40,350 --> 00:52:38,650
smooth right so so we don't know where

1185
00:52:42,250 --> 00:52:40,360
this object is coming from many people

1186
00:52:44,260 --> 00:52:42,260
have tried to do that to see if they

1187
00:52:45,730 --> 00:52:44,270
probably like the star or stellar

1188
00:52:47,830 --> 00:52:45,740

Association what the obvious might be

1189
00:52:51,160 --> 00:52:47,840
coming from and they try to do that by

1190
00:52:52,840 --> 00:52:51,170
estimating how fast it was happening I

1191
00:52:54,310 --> 00:52:52,850
mean they want to have like a close

1192
00:52:56,500 --> 00:52:54,320
encounter but they also want to have

1193
00:52:59,050 --> 00:52:56,510
like a low velocity close encounter and

1194
00:53:00,460 --> 00:52:59,060
and by that maybe you know that's a sign

1195
00:53:02,140 --> 00:53:00,470
that it came from that system but they

1196
00:53:04,780 --> 00:53:02,150
haven't been able to pinpoint the system

1197
00:53:07,000 --> 00:53:04,790
I'd imagine traveling as fast as it is

1198
00:53:09,280 --> 00:53:07,010
it would be skipping back and forth

1199
00:53:21,100 --> 00:53:09,290
between gravity wells and poles of

1200
00:53:22,870 --> 00:53:21,110
different galaxies alright so that

1201
00:53:24,910 --> 00:53:22,880
brings me to the end of the ones I wrote

1202
00:53:28,960 --> 00:53:24,920
down let me check the chat to see do we

1203
00:53:31,230 --> 00:53:28,970
have time for one more yes I guess I

1204
00:53:35,320 --> 00:53:31,240
wrote down a question in terms of the

1205
00:53:37,900 --> 00:53:35,330
radiation pressure okay you know because

1206
00:53:40,480 --> 00:53:37,910
you've got a hundred meter sized object

1207
00:53:42,550 --> 00:53:40,490
and to get like aerogel out to a hundred

1208
00:53:45,880 --> 00:53:42,560
meters feels like it would be extremely

1209
00:53:49,330 --> 00:53:45,890
fragile and then slingshot that across

1210
00:53:52,060 --> 00:53:49,340
interstellar space does the low density

1211
00:53:55,870 --> 00:53:52,070
have a limit to the size that you can

1212
00:54:00,750 --> 00:53:55,880
build it yeah there was there was a

1213
00:54:03,520 --> 00:54:00,760

study to see how fragile this object is

1214
00:54:05,140 --> 00:54:03,530
only subject to because when it's travel

1215
00:54:07,510 --> 00:54:05,150
in interstellar space you have all these

1216
00:54:09,760 --> 00:54:07,520
tidal forces this rotation you can have

1217
00:54:11,500 --> 00:54:09,770
this rational divert you can have

1218
00:54:13,870 --> 00:54:11,510
rotational disruption and you have these

1219
00:54:17,110 --> 00:54:13,880
tidal forces and actually they the

1220
00:54:19,030 --> 00:54:17,120
conclusion that was that not yet with a

1221
00:54:23,170 --> 00:54:19,040
fractal structure of such a low density

1222
00:54:24,880 --> 00:54:23,180
could survive another thing is what we

1223
00:54:27,970 --> 00:54:24,890
don't know if it if it could have

1224
00:54:30,010 --> 00:54:27,980
survived the ejection from its host

1225
00:54:32,800 --> 00:54:30,020
planetary system that we don't know but

1226
00:54:37,180 --> 00:54:32,810
apparently such an object could have

1227
00:54:38,820 --> 00:54:37,190
survived interstellar trouble but you

1228
00:54:40,900 --> 00:54:38,830
know there are many open questions and

1229
00:54:42,760 --> 00:54:40,910
unfortunately we cannot observe the

1230
00:54:43,990 --> 00:54:42,770
Saudi attack shows right I mean it will

1231
00:54:45,940 --> 00:54:44,000
be great to have like a spacecraft

1232
00:54:48,010 --> 00:54:45,950
traveling to one of these subjects and

1233
00:54:49,060 --> 00:54:48,020
people are actually thinking about doing

1234
00:54:52,450 --> 00:54:49,070
that the problem is that these things

1235
00:54:54,310 --> 00:54:52,460
are very very fast and in order to send

1236
00:54:55,870 --> 00:54:54,320
a spacecraft to one of these objects and

1237
00:54:59,380 --> 00:54:55,880
you will basically have to

1238
00:55:03,309 --> 00:54:59,390

a spacecraft ready somewhere you know in

1239
00:55:06,490 --> 00:55:03,319
an orbit on 13 somewhere and he actually

1240
00:55:08,440 --> 00:55:06,500
has such a proposal but the problem with

1241
00:55:10,180 --> 00:55:08,450
that is that even if there is an

1242
00:55:13,749 --> 00:55:10,190
interstellar coming coming and you have

1243
00:55:18,009 --> 00:55:13,759
this spacecraft ready in l2 in the case

1244
00:55:20,289 --> 00:55:18,019
of this mission by ISA you are still

1245
00:55:21,940 --> 00:55:20,299
need to go to the Audion and unless the

1246
00:55:25,210 --> 00:55:21,950
object gets very close to where the

1247
00:55:28,089 --> 00:55:25,220
spacecraft is its park you wouldn't get

1248
00:55:29,650 --> 00:55:28,099
there as fast and none but there are

1249
00:55:31,539 --> 00:55:29,660
other people that are suggesting to use

1250
00:55:35,470 --> 00:55:31,549
like really noble propulsion methods

1251
00:55:39,999 --> 00:55:35,480
like using a laser from Earth

1252
00:55:42,640 --> 00:55:40,009
so like push them right to push the

1253
00:55:44,079 --> 00:55:42,650
spacecraft yeah and then also there are

1254
00:55:46,539 --> 00:55:44,089
only people suggesting to use solar

1255
00:55:50,049 --> 00:55:46,549
cells and so these would be for the

1256
00:55:51,880 --> 00:55:50,059
small spacecraft but so there is a lot

1257
00:55:54,519 --> 00:55:51,890
of possibilities right that people are

1258
00:55:55,839 --> 00:55:54,529
exploring because having a close in

1259
00:55:57,910 --> 00:55:55,849
contact with one of these interstellar

1260
00:56:00,190 --> 00:55:57,920
of this will be necessarily gnarly it

1261
00:56:03,069 --> 00:56:00,200
would be it's important to give some

1262
00:56:04,720 --> 00:56:03,079
context for close encounter as well

1263
00:56:06,220 --> 00:56:04,730

because I think oftentimes we forget

1264
00:56:10,749 --> 00:56:06,230
when we're talking about space it's very

1265
00:56:14,440 --> 00:56:10,759
hard to close encounter in space is such

1266
00:56:16,509 --> 00:56:14,450
a huge amount of distant well yes it

1267
00:56:18,849 --> 00:56:16,519
just getting a bit closer alright so you

1268
00:56:20,680 --> 00:56:18,859
can do observations that are you know

1269
00:56:23,769 --> 00:56:20,690
you can actually observe it and he's

1270
00:56:25,210 --> 00:56:23,779
more than a dot right yes okay so I mean

1271
00:56:26,950 --> 00:56:25,220
they're beautiful disclosing contacts

1272
00:56:28,720 --> 00:56:26,960
with comments right and you see the

1273
00:56:30,700 --> 00:56:28,730
comments they are absolutely beautiful

1274
00:56:34,240 --> 00:56:30,710
these odd shapes and then you see the

1275
00:56:37,029 --> 00:56:34,250
debts and this is stunning right what is

1276
00:56:40,450 --> 00:56:37,039
a spacecraft kind of sharp and of course

1277
00:56:41,680 --> 00:56:40,460
it was really cool to do a return

1278
00:56:43,630 --> 00:56:41,690
mission but that's even more difficult

1279
00:56:45,490 --> 00:56:43,640
for an extra I mean it is all really

1280
00:56:47,499 --> 00:56:45,500
difficult for it's a large system body

1281
00:56:49,210 --> 00:56:47,509
that is moving at the original velocity

1282
00:56:52,960 --> 00:56:49,220
for something that this movie like you

1283
00:56:54,549 --> 00:56:52,970
know like a bat out of hell able to pick

1284
00:56:57,370 --> 00:56:54,559
up something and bring it back to the

1285
00:56:59,859 --> 00:56:57,380
lab to analyze it even just to get

1286
00:57:02,499 --> 00:56:59,869
observations of it I know the dlci

1287
00:57:04,390 --> 00:57:02,509
scheduling team works very hard to get

1288
00:57:05,829 --> 00:57:04,400

observations just of something fast

1289
00:57:08,450 --> 00:57:05,839
moving like a Mulla Mulla because the

1290
00:57:10,400 --> 00:57:08,460
entire timeline had to change yes

1291
00:57:11,660 --> 00:57:10,410
it's ugly exact even just pointing the

1292
00:57:16,760 --> 00:57:11,670
telescope much less getting in

1293
00:57:19,130 --> 00:57:16,770
spacecraft but if date honesty it's you

1294
00:57:20,510 --> 00:57:19,140
know if we have the Soviets when JW seen

1295
00:57:23,089 --> 00:57:20,520
its online that's going to be fantastic

1296
00:57:24,500 --> 00:57:23,099
right and we probably have in the

1297
00:57:27,740 --> 00:57:24,510
lifetime of the embassy we're probably

1298
00:57:29,300 --> 00:57:27,750
half way right so that brings up a final

1299
00:57:33,380 --> 00:57:29,310
question is how many of these do we

1300
00:57:35,570 --> 00:57:33,390
expect to observe per decade okay so Jay

1301
00:57:37,670 --> 00:57:35,580
does T's got a five to 10-year lifespan

1302
00:57:42,589 --> 00:57:37,680
how many of them will come through the

1303
00:57:43,190 --> 00:57:42,599
solar sorry a couple per year so per

1304
00:57:49,130 --> 00:57:43,200
decade

1305
00:57:51,829 --> 00:57:49,140
you know it's affirm a few dozen yeah so

1306
00:57:53,329 --> 00:57:51,839
I mean it's not that you can do these

1307
00:57:55,280 --> 00:57:53,339
things with a few dozen right but it

1308
00:58:00,290 --> 00:57:55,290
will help us to start collecting these

1309
00:58:02,690 --> 00:58:00,300
in the population right that's how we

1310
00:58:04,300 --> 00:58:02,700
build science by you know I guess many

1311
00:58:08,480 --> 00:58:04,310
statistics a little by little a little

1312
00:58:09,920 --> 00:58:08,490
these things before because one thing

1313
00:58:12,920 --> 00:58:09,930

that I still don't understand is that

1314
00:58:16,520 --> 00:58:12,930
you know pan-starrs has been looking for

1315
00:58:19,579 --> 00:58:16,530
these things it was part of the one of

1316
00:58:23,030 --> 00:58:19,589
the goals right and and it's not that

1317
00:58:24,500 --> 00:58:23,040
these people have been looking for these

1318
00:58:27,890 --> 00:58:24,510
things before but they have not been

1319
00:58:30,440 --> 00:58:27,900
identified so so maybe there is you know

1320
00:58:31,579 --> 00:58:30,450
people go into the archives and looking

1321
00:58:34,670 --> 00:58:31,589
at their kids they might be able to

1322
00:58:37,280 --> 00:58:34,680
identify these these objects that were

1323
00:58:41,480 --> 00:58:37,290
detected in the past but not identify so

1324
00:58:43,910 --> 00:58:41,490
I hope people are working on that I'm

1325
00:58:46,099 --> 00:58:43,920
sure they are all right granted we have

1326
00:58:50,510 --> 00:58:46,109
any more questions or are we gonna are

1327
00:58:50,839 --> 00:58:50,520
we done here sounds like we're done all

1328
00:58:54,170 --> 00:58:50,849
right

1329
00:58:56,120 --> 00:58:54,180
thank you so much that really is it's

1330
00:58:57,859 --> 00:58:56,130
exciting field to know that we're

1331
00:59:00,020 --> 00:58:57,869
actually studying interstellar

1332
00:59:02,630 --> 00:59:00,030
interlopers to our solar system and that

1333
00:59:05,120 --> 00:59:02,640
there is a great chance of studying

1334
00:59:07,430 --> 00:59:05,130
others we can't decide study one meant

1335
00:59:08,839 --> 00:59:07,440
multiple times but by studying many of

1336
00:59:10,550 --> 00:59:08,849
them we could sort of build up the

1337
00:59:14,510 --> 00:59:10,560
statistics and they understanding of

1338
00:59:17,570 --> 00:59:14,520

these interstellar lopers all right next

1339
00:59:20,450 --> 00:59:17,580
month on August 4th just to remind you

1340
00:59:21,130 --> 00:59:20,460
armchair astrophysics finding physics

1341
00:59:23,500 --> 00:59:21,140
far

1342
00:59:25,750 --> 00:59:23,510
and wide by Quinn heart of the Space

1343
00:59:26,289 --> 00:59:25,760
Telescope Science Institute wheeze join

1344
00:59:30,099 --> 00:59:26,299
us then

1345
00:59:38,790 --> 00:59:30,109
and until then keep looking up and enjoy