

1
00:00:04,629 --> 00:00:08,780
hello holders and welcome to this week's

2
00:00:07,219 --> 00:00:10,699
hub will hang out my name is Tony

3
00:00:08,779 --> 00:00:12,379
Darnell I work at the Space Telescope

4
00:00:10,699 --> 00:00:13,969
Science Institute and this week we've

5
00:00:12,380 --> 00:00:16,219
had another really great hangout plan

6
00:00:13,970 --> 00:00:17,630
for you this week astronomers using the

7
00:00:16,219 --> 00:00:20,590
Hubble Space Telescope have been

8
00:00:17,629 --> 00:00:24,019
pointing it at black hole Jets in NGC

9
00:00:20,589 --> 00:00:25,399
3862 a galaxy it is very far away and

10
00:00:24,019 --> 00:00:27,469
that we will learn a lot more about

11
00:00:25,399 --> 00:00:29,599
during the course of this hangout and so

12
00:00:27,469 --> 00:00:32,028
we will be learning about black hole

13
00:00:29,600 --> 00:00:33,890
supermassive black holes by cold Jets as

14
00:00:32,029 --> 00:00:35,899
well as colliding material within those

15
00:00:33,890 --> 00:00:37,819
Jets but before I get started let me

16
00:00:35,899 --> 00:00:39,920
introduce my co-host because this week

17
00:00:37,819 --> 00:00:41,690
we've got a full gang we got everybody

18
00:00:39,920 --> 00:00:43,309
here this week I have with me dr. carol

19
00:00:41,689 --> 00:00:46,128
christian she's the Hubble Space

20
00:00:43,308 --> 00:00:47,959
Telescope every scientist for the hubble

21
00:00:46,128 --> 00:00:50,780
space telescope project from the

22
00:00:47,960 --> 00:00:52,969
Institute and hello Carol and I'm also

23
00:00:50,780 --> 00:00:55,338
with me is Scott Lewis he's driving the

24
00:00:52,969 --> 00:00:56,959
internet how you feeling Scott a much

25
00:00:55,338 --> 00:01:00,128
every language past week you were out

26
00:00:56,959 --> 00:01:02,839
what I missed you guys I'm just miss you

27
00:01:00,128 --> 00:01:04,158
glad you're back I miss you you're glad

28
00:01:02,838 --> 00:01:06,590
if we didn't get what happens you had

29

00:01:04,159 --> 00:01:07,880
pretty much it there's a good reason

30
00:01:06,590 --> 00:01:11,390
we're on opposite sides of the country

31
00:01:07,879 --> 00:01:12,890
to show my spelling yeah so before I

32
00:01:11,390 --> 00:01:14,780
introduce our guest let me just let you

33
00:01:12,890 --> 00:01:17,150
know that we want you to interact with

34
00:01:14,780 --> 00:01:18,260
us in this hangout and you can do that

35
00:01:17,150 --> 00:01:19,400
in a variety of ways which I'm going to

36
00:01:18,260 --> 00:01:20,870
have Scott tell you about in just a

37
00:01:19,400 --> 00:01:22,550
minute but first I want to also remind

38
00:01:20,870 --> 00:01:25,070
you that if you have not followed us on

39
00:01:22,549 --> 00:01:27,079
Twitter we are at Hubble telescope and

40
00:01:25,069 --> 00:01:28,189
you'll be getting all you can get all

41
00:01:27,079 --> 00:01:30,170
the news latest news and information

42
00:01:28,189 --> 00:01:32,599
about these hangouts from there and also

43
00:01:30,170 --> 00:01:34,070

subscribe to our YouTube channel Hubble

44

00:01:32,599 --> 00:01:35,539
site channel and you can also get

45

00:01:34,069 --> 00:01:37,519
notifications from us there we got a lot

46

00:01:35,540 --> 00:01:39,680
of cool stuff on that channel as well so

47

00:01:37,519 --> 00:01:42,409
Scott how can people interact with us

48

00:01:39,680 --> 00:01:45,320
throughout this hangout so the best way

49

00:01:42,409 --> 00:01:47,899
to get in touch with us is using the Q&A

50

00:01:45,319 --> 00:01:50,059
app which is on both YouTube and Google+

51

00:01:47,900 --> 00:01:52,340
so as we're broadcasting right now and

52

00:01:50,060 --> 00:01:53,390
if you're watching it later on you can

53

00:01:52,340 --> 00:01:54,829
stay at the very bottom that we're

54

00:01:53,390 --> 00:01:56,689
answering questions and if you're

55

00:01:54,829 --> 00:01:58,310
watching us live you can put questions

56

00:01:56,689 --> 00:02:00,859
in there will see them up here on our

57

00:01:58,310 --> 00:02:02,359
right hand side and as we respond to

58
00:02:00,859 --> 00:02:04,489
them will put a timestamp on so you can

59
00:02:02,359 --> 00:02:07,670
see when we're applying those specific

60
00:02:04,489 --> 00:02:10,098
questions and also as Tony said that we

61
00:02:07,670 --> 00:02:13,248
are Twitter so I am monitoring both the

62
00:02:10,098 --> 00:02:14,000
hashtag see here hubble 25 and as Tony's

63
00:02:13,248 --> 00:02:16,879
lower third show

64
00:02:14,000 --> 00:02:18,289
is a hashtag hubble hang out and stuff a

65
00:02:16,879 --> 00:02:19,939
monitoring both of those and we'll be

66
00:02:18,289 --> 00:02:21,949
posting some pictures as we're going on

67
00:02:19,939 --> 00:02:24,289
as well as the the links to keep people

68
00:02:21,949 --> 00:02:26,629
and keep all you guys involved in the

69
00:02:24,289 --> 00:02:27,919
conversation all right thanks God now my

70
00:02:26,629 --> 00:02:29,240
favorite way to do it is with the Q&A

71
00:02:27,919 --> 00:02:30,739
app because I have it right here and I

72
00:02:29,240 --> 00:02:32,600
can see you guys right away so that

73
00:02:30,740 --> 00:02:34,520
would be the easiest way so I can

74
00:02:32,599 --> 00:02:37,340
interject the conversation if it's if

75
00:02:34,520 --> 00:02:40,159
it's a timely comment so uh let's get to

76
00:02:37,340 --> 00:02:42,170
today's hangout as I'm anybody who knows

77
00:02:40,159 --> 00:02:43,669
anything about the movement watch these

78
00:02:42,169 --> 00:02:45,500
hangouts for any length of time knows

79
00:02:43,669 --> 00:02:47,719
that the Hubble Space Telescope has been

80
00:02:45,500 --> 00:02:50,780
orbiting above our heads for the last 14

81
00:02:47,719 --> 00:02:53,449
25 years and one of the great advantages

82
00:02:50,780 --> 00:02:55,759
that gives us to Fred for it to have a

83
00:02:53,449 --> 00:02:58,219
telescope up in orbit for so long is

84
00:02:55,759 --> 00:02:59,750
that we can use it to periodically go

85
00:02:58,219 --> 00:03:01,849
back and look at some things that had

86

00:02:59,750 --> 00:03:04,009
looked at before and that's what these

87
00:03:01,849 --> 00:03:05,900
the astronomers we have with us today

88
00:03:04,009 --> 00:03:08,239
have done they have looked at a galaxy

89
00:03:05,900 --> 00:03:09,379
I've already said NGC 3862 which we'll

90
00:03:08,239 --> 00:03:11,239
learn a little bit more about they've

91
00:03:09,379 --> 00:03:13,519
looked at it at four different instances

92
00:03:11,239 --> 00:03:18,049
over the last 20 or so years and have

93
00:03:13,520 --> 00:03:19,670
been able to see features in this a jet

94
00:03:18,049 --> 00:03:22,280
coming from a supermassive black hole

95
00:03:19,669 --> 00:03:24,469
which is unbelievably great i meant the

96
00:03:22,280 --> 00:03:26,390
days of a static universe are clearly

97
00:03:24,469 --> 00:03:28,879
over we can see all kinds of cool things

98
00:03:26,389 --> 00:03:31,159
going on and so with me today is dr.

99
00:03:28,879 --> 00:03:32,870
Eileen Meyer she's she's the leader

100
00:03:31,159 --> 00:03:35,659

author of the paper paper also with me

101

00:03:32,870 --> 00:03:38,539

is dr. Roland van tomorrow and dr.

102

00:03:35,659 --> 00:03:39,979

Marcus georgopoulos there they have all

103

00:03:38,539 --> 00:03:43,489

published a paper which appeared in

104

00:03:39,979 --> 00:03:44,869

today's issue of the journal Nature so

105

00:03:43,489 --> 00:03:47,329

welcome guys and it's good to have you

106

00:03:44,870 --> 00:03:49,519

in our hangout thank you good to be here

107

00:03:47,329 --> 00:03:50,870

thanks Eileen let me start with you a

108

00:03:49,519 --> 00:03:53,209

little bit I want to talk about black

109

00:03:50,870 --> 00:03:56,030

holes first now we've said this before

110

00:03:53,209 --> 00:03:58,519

in previous hangouts but galaxies not

111

00:03:56,030 --> 00:04:01,250

all but most seem to have something

112

00:03:58,519 --> 00:04:03,349

called a supermassive black hole in them

113

00:04:01,250 --> 00:04:06,439

now what is the supermassive black hole

114

00:04:03,349 --> 00:04:08,900

you describe that for us uh yes it's

115
00:04:06,439 --> 00:04:11,060
very roughly somewhere between a million

116
00:04:08,900 --> 00:04:13,610
to a billion times the mass of our Sun

117
00:04:11,060 --> 00:04:15,979
that's a pretty big that's the it's a

118
00:04:13,610 --> 00:04:17,359
big range but it's you know in astronomy

119
00:04:15,979 --> 00:04:19,728
we lot of times deal with order of

120
00:04:17,358 --> 00:04:21,349
magnitude differences so that's that's

121
00:04:19,728 --> 00:04:23,449
sort of the supermassive black hole

122
00:04:21,350 --> 00:04:27,410
category what we call a stellar mass

123
00:04:23,449 --> 00:04:30,560
black hole might only be one time 28

124
00:04:27,410 --> 00:04:32,090
15 times the mass of our Sun there's a

125
00:04:30,560 --> 00:04:34,670
whole range in the middle that's kind of

126
00:04:32,089 --> 00:04:36,769
lumped into intermediate mats so that's

127
00:04:34,670 --> 00:04:38,180
sort of the category we would be

128
00:04:36,769 --> 00:04:41,180
something that might be formed from a

129
00:04:38,180 --> 00:04:42,530
very large super giant explosion or the

130
00:04:41,180 --> 00:04:44,540
death of a supergiant stars right

131
00:04:42,529 --> 00:04:46,879
generates a star exactly now so these

132
00:04:44,540 --> 00:04:48,530
supermassive black holes these are as

133
00:04:46,879 --> 00:04:52,490
you said a million to a billion times

134
00:04:48,529 --> 00:04:56,089
larger and the Sun and most galaxies

135
00:04:52,490 --> 00:04:57,170
seem to have these but you know it do

136
00:04:56,089 --> 00:04:59,029
you think that you're what do you think

137
00:04:57,170 --> 00:05:01,730
causes these things to it to happen is

138
00:04:59,029 --> 00:05:03,949
there any ideas about why they would get

139
00:05:01,730 --> 00:05:06,770
so large or do they happen over time are

140
00:05:03,949 --> 00:05:10,310
they to collate a coalition of a lot of

141
00:05:06,769 --> 00:05:12,199
other black holes are very possibly and

142
00:05:10,310 --> 00:05:13,670
this is one of those things that you

143

00:05:12,199 --> 00:05:15,319
know nature is weirder than our

144
00:05:13,670 --> 00:05:17,000
imagination I don't think if you went

145
00:05:15,319 --> 00:05:18,349
back to astronomy before we knew about

146
00:05:17,000 --> 00:05:19,879
these things people would have said oh

147
00:05:18,350 --> 00:05:21,290
yeah there's a there's black holes a

148
00:05:19,879 --> 00:05:23,569
billion times the mass of our Sun we

149
00:05:21,290 --> 00:05:25,819
only you know we're trying to understand

150
00:05:23,569 --> 00:05:27,379
that that mystery it's it's a it's one

151
00:05:25,819 --> 00:05:29,680
of the things that's still open so we

152
00:05:27,379 --> 00:05:32,750
know that they grow they get bigger

153
00:05:29,680 --> 00:05:34,759
partly by accreting matter so they form

154
00:05:32,750 --> 00:05:36,529
these big discs of gas and dust that

155
00:05:34,759 --> 00:05:40,099
fall into the black hole so they can

156
00:05:36,529 --> 00:05:43,579
grow that way but we also think we know

157
00:05:40,100 --> 00:05:45,169

that this is not fast enough given the

158

00:05:43,579 --> 00:05:46,668

the lifetime of the universe to grow

159

00:05:45,168 --> 00:05:50,629

these as big as they are so there must

160

00:05:46,668 --> 00:05:52,729

have been some more direct collapse mode

161

00:05:50,629 --> 00:05:54,409

of forming the original seeds for these

162

00:05:52,730 --> 00:05:56,689

black holes but it's a big mystery that

163

00:05:54,410 --> 00:05:59,270

we're trying to figure out now and these

164

00:05:56,689 --> 00:06:00,439

these these Jets these are the ones that

165

00:05:59,269 --> 00:06:01,909

you've been observing and we'll talk

166

00:06:00,439 --> 00:06:03,469

about here in just a little bit do all

167

00:06:01,910 --> 00:06:04,820

black holes have them and and I always

168

00:06:03,470 --> 00:06:07,040

thought that when things fell into a

169

00:06:04,819 --> 00:06:08,209

black hole they kind of disappeared you

170

00:06:07,040 --> 00:06:09,439

couldn't they couldn't come back out

171

00:06:08,209 --> 00:06:12,259

again how can things are coming out of

172
00:06:09,439 --> 00:06:14,990
black holes here uh that's a very good

173
00:06:12,259 --> 00:06:16,730
question and it's it's a bit of an abuse

174
00:06:14,990 --> 00:06:18,740
of the language when we say oh there's

175
00:06:16,730 --> 00:06:21,050
jets from black holes the truth is this

176
00:06:18,740 --> 00:06:23,540
matter never fell in in the terms of

177
00:06:21,050 --> 00:06:26,240
falling past the event horizon so it's

178
00:06:23,540 --> 00:06:27,950
very close and it's probably on in an

179
00:06:26,240 --> 00:06:30,110
accretion disk at first it's kind of

180
00:06:27,949 --> 00:06:32,209
sliding in towards the black hole but

181
00:06:30,110 --> 00:06:34,009
something about the the disk structure

182
00:06:32,209 --> 00:06:36,288
and the black hole structure kicks it

183
00:06:34,009 --> 00:06:38,689
out so it never really falls in in the

184
00:06:36,288 --> 00:06:40,728
first place to answer an earlier

185
00:06:38,689 --> 00:06:41,149
question jets from black holes are

186
00:06:40,728 --> 00:06:43,310
relative

187
00:06:41,149 --> 00:06:46,699
a rare it's only about maybe ten percent

188
00:06:43,310 --> 00:06:49,310
of these objects that give us jets so

189
00:06:46,699 --> 00:06:52,039
only ten percent of all the super so

190
00:06:49,310 --> 00:06:54,259
they would have a jet so and would they

191
00:06:52,040 --> 00:06:55,760
so is its directly am I right in

192
00:06:54,259 --> 00:06:57,319
assuming it's directly related to things

193
00:06:55,759 --> 00:07:00,170
that are falling into the black hole at

194
00:06:57,319 --> 00:07:02,629
the time so if nothing is going in you

195
00:07:00,170 --> 00:07:04,250
don't get a jet that's yeah broadly

196
00:07:02,629 --> 00:07:08,600
speaking that's that's the case so you

197
00:07:04,250 --> 00:07:10,970
can starve a jet of fuel and presumably

198
00:07:08,600 --> 00:07:13,400
it will turn off now Marcos would like

199
00:07:10,970 --> 00:07:15,710
to add something to that I think okay go

200

00:07:13,399 --> 00:07:17,419
ahead Marcos yeah basically you can

201
00:07:15,709 --> 00:07:19,399
start on a black hole if you don't see

202
00:07:17,420 --> 00:07:23,210
the black hole I'm a supermassive black

203
00:07:19,399 --> 00:07:25,639
hole you do not have a quasar it is very

204
00:07:23,209 --> 00:07:27,709
bright point like sources in the center

205
00:07:25,639 --> 00:07:30,620
of galaxies but you still have a black

206
00:07:27,709 --> 00:07:32,810
hole that is just sitting there like the

207
00:07:30,620 --> 00:07:34,069
only having our galactic center right

208
00:07:32,810 --> 00:07:36,170
exactly i was going to say the one in

209
00:07:34,069 --> 00:07:38,540
our galaxy right now is quiet correct so

210
00:07:36,170 --> 00:07:41,060
basically as far as we understand things

211
00:07:38,540 --> 00:07:44,420
every single galaxy has a supermassive

212
00:07:41,060 --> 00:07:46,220
black hole but in most of the galaxies

213
00:07:44,420 --> 00:07:48,650
these black holes are not shed anymore

214
00:07:46,220 --> 00:07:50,800

the period that they were getting food

215

00:07:48,649 --> 00:07:53,419

from the galactic neighborhood is over

216

00:07:50,800 --> 00:07:55,639

so they are not shed and they are not

217

00:07:53,420 --> 00:07:58,430

they are not what we would call a quasar

218

00:07:55,639 --> 00:08:00,500

meaning an accreting black hole and and

219

00:07:58,430 --> 00:08:02,090

also there is no se pega his jet these

220

00:08:00,500 --> 00:08:07,670

jets and quasars are the same thing

221

00:08:02,089 --> 00:08:10,339

right ah well you can not really you can

222

00:08:07,670 --> 00:08:12,020

have quasars that do not produce that

223

00:08:10,339 --> 00:08:14,359

but they still have this very bright

224

00:08:12,019 --> 00:08:18,109

accretion disks that we see in in the

225

00:08:14,360 --> 00:08:19,550

optical and UV and in the x-rays oh so

226

00:08:18,110 --> 00:08:21,680

this is the difference so the difference

227

00:08:19,550 --> 00:08:23,990

is that they will be the quasars d is

228

00:08:21,680 --> 00:08:25,850

the radiating accreting this then from

229
00:08:23,990 --> 00:08:28,220
the black hole that's right so you have

230
00:08:25,850 --> 00:08:31,010
quasars you have quasar that have just

231
00:08:28,220 --> 00:08:33,290
an accretion disk and you have quasars I

232
00:08:31,009 --> 00:08:36,799
have an accretion disk + the Jets coming

233
00:08:33,289 --> 00:08:41,059
out now what makes a difference between

234
00:08:36,799 --> 00:08:44,240
these two families we do not know at

235
00:08:41,059 --> 00:08:47,689
this stage it's not clear what is the

236
00:08:44,240 --> 00:08:49,279
difference and these things look very

237
00:08:47,690 --> 00:08:51,170
similar if you look at them in the

238
00:08:49,279 --> 00:08:52,789
optical will be with a space with a

239
00:08:51,169 --> 00:08:54,889
telescope like the Space Telescope they

240
00:08:52,789 --> 00:08:57,078
look pretty similar those at 58

241
00:08:54,889 --> 00:08:58,938
was that you know and it's a film about

242
00:08:57,078 --> 00:09:00,708
the research to figure out what makes

243
00:08:58,938 --> 00:09:04,039
some of them produce debt and some of

244
00:09:00,708 --> 00:09:05,238
them want to use it okay so let's talk

245
00:09:04,039 --> 00:09:06,769
about the wavelengths a little bit now

246
00:09:05,239 --> 00:09:08,778
you would this was first discovered i

247
00:09:06,769 --> 00:09:13,278
think in ninety this jet was first

248
00:09:08,778 --> 00:09:14,688
discovered in 3862 in 92 i believe and

249
00:09:13,278 --> 00:09:16,519
then and then it was and then it was

250
00:09:14,688 --> 00:09:20,358
observed for the first time by hubble in

251
00:09:16,519 --> 00:09:22,039
94 in the new said it was visible in

252
00:09:20,359 --> 00:09:23,839
optical what are the wavelengths are

253
00:09:22,039 --> 00:09:27,828
these things very bright in on talking

254
00:09:23,839 --> 00:09:29,809
about the Jets themselves it wants to

255
00:09:27,828 --> 00:09:33,168
take that one I'll let me let me call

256
00:09:29,808 --> 00:09:35,509
mr. in a general sense what is happening

257

00:09:33,168 --> 00:09:37,159
with black holes so you have something

258
00:09:35,509 --> 00:09:39,678
that is very small and very massive

259
00:09:37,159 --> 00:09:42,078
sitting in the center of a galaxy and in

260
00:09:39,678 --> 00:09:45,350
fact it's so small that it's a black

261
00:09:42,078 --> 00:09:48,078
hole you have material in the galaxy

262
00:09:45,350 --> 00:09:50,989
stars have stars and gas and dust are

263
00:09:48,078 --> 00:09:55,008
all things you find in galaxies and the

264
00:09:50,989 --> 00:09:57,109
gas has a tendency to you know fall into

265
00:09:55,009 --> 00:09:58,759
the center and when you have a lot of

266
00:09:57,109 --> 00:10:01,429
gas that you try to squeeze in a very

267
00:09:58,759 --> 00:10:03,168
small volume you get friction so the gas

268
00:10:01,428 --> 00:10:05,509
basically as friction with itself and it

269
00:10:03,168 --> 00:10:07,308
gets very hot so what happens in all of

270
00:10:05,509 --> 00:10:09,980
these cases when there is material

271
00:10:07,308 --> 00:10:12,278

falling onto a black hole you have very

272

00:10:09,980 --> 00:10:14,778

hot gas that sits next to it and that

273

00:10:12,278 --> 00:10:16,548

produces radiation and emission that you

274

00:10:14,778 --> 00:10:18,230

can see in various wavelengths so

275

00:10:16,548 --> 00:10:20,539

something that's very conspicuous in all

276

00:10:18,230 --> 00:10:22,339

wavelengths is x-ray emission because

277

00:10:20,539 --> 00:10:26,568

when you have material that gets about a

278

00:10:22,339 --> 00:10:28,549

million degrees its natural wavelengths

279

00:10:26,568 --> 00:10:31,099

in which it radiates is x-ray emission

280

00:10:28,548 --> 00:10:32,749

okay something is that the dominant

281

00:10:31,100 --> 00:10:36,319

wavelength for this then or these Jets

282

00:10:32,749 --> 00:10:37,519

uh not for the Jets necessarily but for

283

00:10:36,318 --> 00:10:40,578

the accretion disk so you're always

284

00:10:37,519 --> 00:10:42,019

repeating the there's many source you

285

00:10:40,578 --> 00:10:43,099

know bright sources going on so you have

286
00:10:42,019 --> 00:10:44,869
the accretion disk and then you also

287
00:10:43,100 --> 00:10:49,639
have the Jets and they have very

288
00:10:44,869 --> 00:10:52,839
distinct wavelength distributions so for

289
00:10:49,639 --> 00:10:55,970
the Jets actually another name for

290
00:10:52,839 --> 00:10:58,459
sources black holes with jets is called

291
00:10:55,970 --> 00:11:01,309
radio loud active galaxies and the

292
00:10:58,458 --> 00:11:02,719
reason we call them radio loud is

293
00:11:01,308 --> 00:11:05,568
because they produce a lot of radio

294
00:11:02,720 --> 00:11:07,129
emission so and that's that's a process

295
00:11:05,568 --> 00:11:10,699
called synchrotron emission

296
00:11:07,129 --> 00:11:15,019
and so probably you would say that the

297
00:11:10,700 --> 00:11:17,330
the dominant emission is is radio in the

298
00:11:15,019 --> 00:11:20,509
sense that that's really the easiest way

299
00:11:17,330 --> 00:11:23,840
to pick up a jet radio loud say it again

300
00:11:20,509 --> 00:11:27,049
radio loud what radio loud active

301
00:11:23,840 --> 00:11:29,180
galaxies electric galaxy yes or if not

302
00:11:27,049 --> 00:11:34,039
not be welcome on a bus I would imagine

303
00:11:29,179 --> 00:11:37,519
okay but they also give you plenty of

304
00:11:34,039 --> 00:11:40,069
optical x-ray UV all the way up to gamma

305
00:11:37,519 --> 00:11:42,439
rays even TV level of mission which is

306
00:11:40,070 --> 00:11:45,200
harder than gamma rays so they're

307
00:11:42,440 --> 00:11:47,180
they're totally multi-wavelength emitter

308
00:11:45,200 --> 00:11:49,129
so you will get the whole entire

309
00:11:47,179 --> 00:11:50,689
spectrum covered and these guys so if

310
00:11:49,129 --> 00:11:53,000
you have you know a suite of instruments

311
00:11:50,690 --> 00:11:54,170
which we do fortunately as astronomers

312
00:11:53,000 --> 00:11:56,389
you can actually take pictures of these

313
00:11:54,169 --> 00:11:58,069
in all kinds of different wavelengths

314

00:11:56,389 --> 00:11:59,840
okay well thanks for the back okay so

315
00:11:58,070 --> 00:12:01,070
that good so now we with that background

316
00:11:59,840 --> 00:12:02,899
folks let's talk about a little bit

317
00:12:01,070 --> 00:12:04,010
about what these guys have done so over

318
00:12:02,899 --> 00:12:05,600
the years Hubble has looked at this

319
00:12:04,009 --> 00:12:07,189
we've talked about it before and Scott

320
00:12:05,600 --> 00:12:09,290
would you mind putting up one of the

321
00:12:07,190 --> 00:12:11,360
graphics that shows the the jet with the

322
00:12:09,289 --> 00:12:12,829
different panels on the side from the

323
00:12:11,360 --> 00:12:14,509
different observations when you get a

324
00:12:12,830 --> 00:12:15,920
chance in and while he's bringing that

325
00:12:14,509 --> 00:12:18,139
up let me talk to me ask you Eileen

326
00:12:15,919 --> 00:12:20,779
describe for us a little bit about your

327
00:12:18,139 --> 00:12:24,110
research and what this paper is is

328
00:12:20,779 --> 00:12:26,929

trying to show us as God has a an image

329

00:12:24,110 --> 00:12:29,750

here of some of the observations right

330

00:12:26,929 --> 00:12:31,579

so going back to something you said at

331

00:12:29,750 --> 00:12:33,350

the beginning we are now at the stage

332

00:12:31,580 --> 00:12:37,100

where Hubble has been up for more than

333

00:12:33,350 --> 00:12:40,340

20 years taking pictures which allows us

334

00:12:37,100 --> 00:12:42,470

to start lining these images of the same

335

00:12:40,340 --> 00:12:46,399

object up and just seeing what's changed

336

00:12:42,470 --> 00:12:50,149

over time and what we found here in this

337

00:12:46,399 --> 00:12:52,399

particular galaxy is that this small jet

338

00:12:50,149 --> 00:12:54,289

coming out it looks here like it's

339

00:12:52,399 --> 00:12:57,289

coming out straight in the plane of the

340

00:12:54,289 --> 00:12:59,389

the sky to the right yes jet is actually

341

00:12:57,289 --> 00:13:02,209

pointed very close to our line of sight

342

00:12:59,389 --> 00:13:05,500

so here's what I do the foul on the left

343
00:13:02,210 --> 00:13:08,600
then is the galaxy basically like a lacy

344
00:13:05,500 --> 00:13:09,830
not gonna from the top right yeah you

345
00:13:08,600 --> 00:13:11,690
can kind of think of it like that

346
00:13:09,830 --> 00:13:14,060
because there's you notice this kind of

347
00:13:11,690 --> 00:13:17,630
grayish disk in the middle this is

348
00:13:14,059 --> 00:13:20,299
actually a very presumably a thin dust

349
00:13:17,629 --> 00:13:21,019
disk that's orbiting around the black

350
00:13:20,299 --> 00:13:23,659
hole

351
00:13:21,019 --> 00:13:26,480
self and we're seeing that face on like

352
00:13:23,659 --> 00:13:28,610
a dinner plate and then the jet is

353
00:13:26,480 --> 00:13:31,070
believed to be almost 90 degrees to this

354
00:13:28,610 --> 00:13:32,960
this face on disk so if that helps you

355
00:13:31,070 --> 00:13:35,300
can kind of now imagine that this jet is

356
00:13:32,960 --> 00:13:38,690
not going to the side it's actually

357
00:13:35,299 --> 00:13:40,399
coming at us just at a slight angle so

358
00:13:38,690 --> 00:13:42,110
that we can kind of still see it see

359
00:13:40,399 --> 00:13:43,730
some of the matter yeah but obviously if

360
00:13:42,110 --> 00:13:45,080
it was tues it you know hundred percent

361
00:13:43,730 --> 00:13:48,320
in our in our face we would just see a

362
00:13:45,080 --> 00:13:50,540
dot so okay so how how far away is this

363
00:13:48,320 --> 00:13:52,310
galaxy this good what are some of the

364
00:13:50,539 --> 00:13:54,799
tell us a little about the galaxy first

365
00:13:52,309 --> 00:13:58,069
then we'll move to the so this is a very

366
00:13:54,799 --> 00:13:59,629
typical environment to see a jet like

367
00:13:58,070 --> 00:14:01,520
this it's it's not a particularly

368
00:13:59,629 --> 00:14:02,779
powerful jet it's actually somewhat low

369
00:14:01,519 --> 00:14:05,329
power compared to the whole population

370
00:14:02,779 --> 00:14:07,370
so it is this is what's called a giant

371

00:14:05,330 --> 00:14:09,230
elliptical galaxy so the stars are quite

372
00:14:07,370 --> 00:14:11,090
smooth in distribution and that's why

373
00:14:09,230 --> 00:14:14,360
you get this kind of smooth halo of

374
00:14:11,090 --> 00:14:17,060
light around the jet that's very typical

375
00:14:14,360 --> 00:14:18,649
this is now you actually said at the

376
00:14:17,059 --> 00:14:20,719
beginning that this is a very faraway

377
00:14:18,649 --> 00:14:22,189
galaxy and it's these are all relative

378
00:14:20,720 --> 00:14:23,990
terms so to an astronomer this is not

379
00:14:22,190 --> 00:14:26,840
far away it's only it's only about 90

380
00:14:23,990 --> 00:14:29,480
megaparsecs so far right of me that's

381
00:14:26,840 --> 00:14:31,340
still the local universe to us so things

382
00:14:29,480 --> 00:14:33,170
things haven't changed much I know but I

383
00:14:31,340 --> 00:14:38,120
hadn't had to work at the store worst

384
00:14:33,169 --> 00:14:40,009
yes yes um yeah so that's that's kind of

385
00:14:38,120 --> 00:14:42,740

the environment right and this is a this

386

00:14:40,009 --> 00:14:44,600

is a large galaxy that's a very old

387

00:14:42,740 --> 00:14:47,180

galaxy if its various political rights

388

00:14:44,600 --> 00:14:49,310

yes so elliptical galaxies as far as

389

00:14:47,179 --> 00:14:53,359

understanding is right now I've gone

390

00:14:49,309 --> 00:14:56,329

through mergers and basically have are

391

00:14:53,360 --> 00:14:58,340

quite old and relaxed and if now kind of

392

00:14:56,330 --> 00:14:59,780

you know mixed up their stars into a

393

00:14:58,340 --> 00:15:01,519

nice little ball if you want to think of

394

00:14:59,779 --> 00:15:03,319

it like that so not the not the

395

00:15:01,519 --> 00:15:07,100

beautiful spiral like we live in but

396

00:15:03,320 --> 00:15:10,310

something much different okay so it's uh

397

00:15:07,100 --> 00:15:12,290

and but but and crucially here there's

398

00:15:10,309 --> 00:15:15,289

got enough material near this black hole

399

00:15:12,289 --> 00:15:18,379

to be feeding you right now right yes

400
00:15:15,289 --> 00:15:20,240
that is apparently the case of course

401
00:15:18,379 --> 00:15:22,189
it's always good to remind people that

402
00:15:20,240 --> 00:15:23,870
we don't have I mean Hubble is amazing

403
00:15:22,190 --> 00:15:26,960
but we don't have the resolution to like

404
00:15:23,870 --> 00:15:29,299
get all the way down and see in fine

405
00:15:26,960 --> 00:15:32,150
detail the accretion disk and in almost

406
00:15:29,299 --> 00:15:33,379
any of these systems that's still that's

407
00:15:32,149 --> 00:15:34,169
still something that you know we're

408
00:15:33,379 --> 00:15:36,419
working on within

409
00:15:34,169 --> 00:15:38,250
mendation okay so so Cara let me ask you

410
00:15:36,419 --> 00:15:41,039
a quick question these these panels on

411
00:15:38,250 --> 00:15:43,769
the left is this all the same um oh can

412
00:15:41,039 --> 00:15:48,120
you put it back on track I now I'm

413
00:15:43,769 --> 00:15:50,370
looking at you I see Scott anyway these

414
00:15:48,120 --> 00:15:52,889
panels on the other right here this is

415
00:15:50,370 --> 00:15:55,799
all it says it so it's all wipsy of what

416
00:15:52,889 --> 00:15:59,129
the wide field camera in this this one f

417
00:15:55,799 --> 00:16:03,389
606 filter um is this all the same

418
00:15:59,129 --> 00:16:05,278
instrument you know so the left is

419
00:16:03,389 --> 00:16:07,409
labeled correctly for that image though

420
00:16:05,278 --> 00:16:09,360
that's just for the galaxy sorry alright

421
00:16:07,409 --> 00:16:11,399
alright yeah cuz that would be

422
00:16:09,360 --> 00:16:17,370
impossible for those of you that know

423
00:16:11,399 --> 00:16:18,659
that 94 um like so the first three of

424
00:16:17,370 --> 00:16:21,929
these images were taken with the

425
00:16:18,659 --> 00:16:25,439
venerable with pic to camera so that's

426
00:16:21,929 --> 00:16:30,870
the first three and then ACS was the the

427
00:16:25,440 --> 00:16:31,740
final epic um so yeah so these are these

428

00:16:30,870 --> 00:16:33,659
are actually mixing different

429
00:16:31,740 --> 00:16:35,430
instruments and slightly different

430
00:16:33,659 --> 00:16:37,350
filters although there as you can see

431
00:16:35,429 --> 00:16:40,469
that we've scaled them to all be roughly

432
00:16:37,350 --> 00:16:42,028
the same wavelength okay I don't know if

433
00:16:40,470 --> 00:16:44,370
it's better to keep with this one or two

434
00:16:42,028 --> 00:16:45,778
go to the the image that Marcos sent us

435
00:16:44,370 --> 00:16:47,578
yesterday i'm not quite sure which is

436
00:16:45,778 --> 00:16:49,439
better the one with all the orange in

437
00:16:47,578 --> 00:16:52,019
its not there might be a better one I

438
00:16:49,440 --> 00:16:53,670
don't know that's a that's a nice one

439
00:16:52,019 --> 00:16:56,578
also because it's a bit more zoomed in

440
00:16:53,669 --> 00:16:59,099
yeah so yeah so getting to the jet

441
00:16:56,578 --> 00:17:01,379
itself we we saw four observations there

442
00:16:59,100 --> 00:17:03,750

over the course of the the past 20 years

443

00:17:01,379 --> 00:17:06,689

where was being is it in remit I

444

00:17:03,750 --> 00:17:09,209

actually have a question and so fast

445

00:17:06,689 --> 00:17:11,009

role in to explain this so we were

446

00:17:09,209 --> 00:17:13,589

talking about elliptical galaxies but

447

00:17:11,009 --> 00:17:21,900

then we have this funny diske thing in

448

00:17:13,588 --> 00:17:25,259

the center so um is is a jet or jet like

449

00:17:21,900 --> 00:17:27,390

features in ellipticals a signature that

450

00:17:25,259 --> 00:17:30,660

there might be more structure than just

451

00:17:27,390 --> 00:17:32,370

smooth elliptical structure or do we

452

00:17:30,660 --> 00:17:34,169

know that there are ellipticals that

453

00:17:32,369 --> 00:17:35,609

have structure that have no jets and

454

00:17:34,169 --> 00:17:38,640

have no black holes or how does that

455

00:17:35,609 --> 00:17:40,949

work I mean I know there's no rule for

456

00:17:38,640 --> 00:17:43,110

every elliptical galaxies but kind of

457
00:17:40,950 --> 00:17:45,409
what's the census of different kinds of

458
00:17:43,109 --> 00:17:47,558
elliptical galaxies and which ones have

459
00:17:45,409 --> 00:17:50,169
black holes and which one

460
00:17:47,558 --> 00:17:52,569
have black holes or jets well so it's a

461
00:17:50,169 --> 00:17:54,850
pretty confusing picture and you know

462
00:17:52,569 --> 00:17:57,908
you basically find other kinds of things

463
00:17:54,849 --> 00:17:59,949
that are not necessarily correlated with

464
00:17:57,909 --> 00:18:03,220
either the type of galaxies or the

465
00:17:59,950 --> 00:18:05,259
orientation of the galaxy the fact that

466
00:18:03,220 --> 00:18:08,230
there is a jet is believed to be

467
00:18:05,259 --> 00:18:10,569
strongly correlated to rotation of the

468
00:18:08,230 --> 00:18:13,089
black hole so black holes have to form

469
00:18:10,569 --> 00:18:15,128
from something from material and most

470
00:18:13,089 --> 00:18:16,869
material in the universe is rotating so

471
00:18:15,128 --> 00:18:19,028
our earth goes around the Sun our Sun is

472
00:18:16,869 --> 00:18:20,618
rotating so whatever it is black hole

473
00:18:19,028 --> 00:18:22,929
forms from has probably had some sense

474
00:18:20,618 --> 00:18:24,398
of rotation to it and that means you end

475
00:18:22,929 --> 00:18:27,038
up with the black hole that as a spin

476
00:18:24,398 --> 00:18:30,008
axis and what tends to happen is that

477
00:18:27,038 --> 00:18:31,509
material comes in sort of an accretion

478
00:18:30,009 --> 00:18:33,878
disk that is perpendicular to this axis

479
00:18:31,509 --> 00:18:35,409
and through some mechanism that we don't

480
00:18:33,878 --> 00:18:38,408
fully understand that presumably

481
00:18:35,409 --> 00:18:40,240
involves magnetic fields some material

482
00:18:38,409 --> 00:18:42,970
gets expelled at very high velocities

483
00:18:40,240 --> 00:18:44,829
along that spin axis and a lot of people

484
00:18:42,970 --> 00:18:47,259
have looked into this question and it

485

00:18:44,829 --> 00:18:49,028
appears that the spin axis of the black

486
00:18:47,259 --> 00:18:51,639
hole or the orientation of the jet is

487
00:18:49,028 --> 00:18:54,220
not in any clearer way correlated with

488
00:18:51,638 --> 00:18:57,359
the orientation of the galaxy or maybe

489
00:18:54,220 --> 00:19:01,149
even the type of the galaxy Wow so a

490
00:18:57,359 --> 00:19:03,579
spiral galaxy galaxies can be active and

491
00:19:01,148 --> 00:19:05,618
they can both of jets and it's not it's

492
00:19:03,579 --> 00:19:08,490
not that this very center is all that

493
00:19:05,618 --> 00:19:11,199
strongly correlated to the grand design

494
00:19:08,490 --> 00:19:13,269
features of the galaxy so in this

495
00:19:11,200 --> 00:19:15,538
particular galaxy we have this

496
00:19:13,269 --> 00:19:19,868
elliptical galaxy and then we have this

497
00:19:15,538 --> 00:19:23,230
diski spinning disk II thing and and the

498
00:19:19,868 --> 00:19:25,329
jet then is somewhat perpendicular to

499
00:19:23,230 --> 00:19:28,360

that so it may be that disc e thing is

500

00:19:25,329 --> 00:19:30,519

actually a little tilted too right yeah

501

00:19:28,359 --> 00:19:32,589

we do we know if the elliptical galaxy

502

00:19:30,519 --> 00:19:35,048

is rotating in the same way or

503

00:19:32,589 --> 00:19:37,449

completely different way or is there are

504

00:19:35,048 --> 00:19:38,888

there any studying spectroscopic studies

505

00:19:37,450 --> 00:19:40,960

of the galaxy itself to know its

506

00:19:38,888 --> 00:19:42,459

rotation I don't know for this

507

00:19:40,960 --> 00:19:45,460

particular galaxy but in general

508

00:19:42,460 --> 00:19:47,350

elliptical galaxies tend to be sort of

509

00:19:45,460 --> 00:19:49,028

the shape of an ellipse taste and sort

510

00:19:47,349 --> 00:19:52,658

of like a flattened football they do

511

00:19:49,028 --> 00:19:54,849

tend in general saying 90% of yeah I'm

512

00:19:52,659 --> 00:19:56,980

to actually rotate in the sense that you

513

00:19:54,849 --> 00:19:59,079

would expect but some fractional

514
00:19:56,980 --> 00:20:01,389
galaxies actually rotate more like a

515
00:19:59,079 --> 00:20:03,218
cigar so they're like cigar shaped

516
00:20:01,388 --> 00:20:05,648
instead of like sort of like a frisbee

517
00:20:03,219 --> 00:20:07,179
so there is some variety until you do

518
00:20:05,648 --> 00:20:08,588
the measurement you can't really tell I

519
00:20:07,179 --> 00:20:11,019
don't know if it's been measured for

520
00:20:08,588 --> 00:20:14,528
this galaxy or no great great thanks

521
00:20:11,019 --> 00:20:19,088
alright so back to the graphics oh yeah

522
00:20:14,528 --> 00:20:21,009
so freaking ok so sorry know that we get

523
00:20:19,088 --> 00:20:22,769
the graphic I wanted to point out

524
00:20:21,009 --> 00:20:25,058
something really funny from Twitter

525
00:20:22,769 --> 00:20:26,858
because we are having some conversation

526
00:20:25,058 --> 00:20:29,288
this from Heather R colada or pillow not

527
00:20:26,858 --> 00:20:30,968
said that she would have a drinking game

528
00:20:29,288 --> 00:20:39,578
where they all do a shot when someone

529
00:20:30,969 --> 00:20:43,749
says accretion disc is coming out I'm

530
00:20:39,578 --> 00:20:47,858
drinking coffee this morning yellow or

531
00:20:43,749 --> 00:20:49,838
an Escrima shot look for that graphic we

532
00:20:47,858 --> 00:20:51,368
were out there which i found i really

533
00:20:49,838 --> 00:20:53,319
like the color and this is wealthy

534
00:20:51,368 --> 00:20:54,278
really able to and in a way that we

535
00:20:53,319 --> 00:20:57,249
haven't all set up so you're actually

536
00:20:54,278 --> 00:20:59,229
able to see the movements over time okay

537
00:20:57,249 --> 00:21:01,028
so I'll have Eileen describe this to us

538
00:20:59,229 --> 00:21:02,469
this is these are the observations there

539
00:21:01,028 --> 00:21:04,690
are some features in here why don't you

540
00:21:02,469 --> 00:21:06,609
describe what we're looking at uh right

541
00:21:04,690 --> 00:21:08,440
so if we start at the very top image

542

00:21:06,608 --> 00:21:11,648
which is how we first saw this jet and

543
00:21:08,440 --> 00:21:13,419
back in 94 so now we've zoomed in and

544
00:21:11,648 --> 00:21:14,798
we've kind of subtracted off the light

545
00:21:13,419 --> 00:21:17,139
from the galaxy just because it makes

546
00:21:14,798 --> 00:21:19,239
things stand out a little better and off

547
00:21:17,138 --> 00:21:21,428
to the left there's a little white cross

548
00:21:19,239 --> 00:21:23,798
might look like a dot to saw you that's

549
00:21:21,429 --> 00:21:25,450
actually where the black hole is and

550
00:21:23,798 --> 00:21:28,148
it's actually very bright at that

551
00:21:25,450 --> 00:21:30,249
location so we also subtracted off the

552
00:21:28,148 --> 00:21:32,588
the light from the core the this is this

553
00:21:30,249 --> 00:21:34,569
black hole also so that we could see the

554
00:21:32,588 --> 00:21:37,690
jet better so that's why that left side

555
00:21:34,569 --> 00:21:40,088
is kind of dark so the jet is coming

556
00:21:37,690 --> 00:21:43,419

from the left rather and moving to the

557

00:21:40,088 --> 00:21:47,769

right and you see 4 knots and these are

558

00:21:43,419 --> 00:21:51,719

creatively naval labeled ABCD and nice

559

00:21:47,769 --> 00:21:56,440

as you will see a blue and back in 96

560

00:21:51,719 --> 00:22:00,489

2000-2014 and very obviously the middle

561

00:21:56,440 --> 00:22:03,459

not here which is not be uh was moving

562

00:22:00,489 --> 00:22:05,379

very very rapidly and we tracked this

563

00:22:03,459 --> 00:22:07,690

the speed and we measured it we found

564

00:22:05,378 --> 00:22:10,298

that it's it appears to be seven times

565

00:22:07,690 --> 00:22:12,849

the speed of light okay what do you mean

566

00:22:10,298 --> 00:22:15,200

appears to be it appears to be because

567

00:22:12,848 --> 00:22:16,939

as we know I hope all of us

568

00:22:15,200 --> 00:22:19,130

I've accepted that nothing moves faster

569

00:22:16,940 --> 00:22:20,298

than the speed of light so that means

570

00:22:19,130 --> 00:22:23,000

that this is actually an optical

571
00:22:20,298 --> 00:22:24,859
illusion this is something that's due to

572
00:22:23,000 --> 00:22:27,019
the Doppler effect it's kind of

573
00:22:24,859 --> 00:22:29,269
analogous to the way sounds get higher

574
00:22:27,019 --> 00:22:30,589
pitched when when like you know an

575
00:22:29,269 --> 00:22:32,480
ambulance or something is coming towards

576
00:22:30,589 --> 00:22:34,069
you same sort of thing happens here

577
00:22:32,480 --> 00:22:36,288
because again remember that this jet is

578
00:22:34,069 --> 00:22:37,939
actually pointed almost directly on our

579
00:22:36,288 --> 00:22:39,710
line of sight right there's a big line

580
00:22:37,940 --> 00:22:41,690
of sight component here and it's moving

581
00:22:39,710 --> 00:22:45,079
at something like ninety-eight percent

582
00:22:41,690 --> 00:22:47,750
the speed of light in real speed and

583
00:22:45,079 --> 00:22:49,730
what happens is as soon as a the light

584
00:22:47,750 --> 00:22:51,919
leaves one of these blobs as its

585
00:22:49,730 --> 00:22:54,319
traveling it literally catches up to its

586
00:22:51,919 --> 00:22:56,389
own light so by the time we observe this

587
00:22:54,319 --> 00:22:58,369
sequence of events on earth the whole

588
00:22:56,388 --> 00:23:01,908
time series is sped up and it looks

589
00:22:58,369 --> 00:23:04,849
faster than it really is so let's say

590
00:23:01,909 --> 00:23:06,409
that again just really clearly yes this

591
00:23:04,849 --> 00:23:08,778
is an effect of the fact that it's

592
00:23:06,409 --> 00:23:11,179
coming towards us yeah it appears to be

593
00:23:08,778 --> 00:23:14,630
going faster than life but don't gives

594
00:23:11,179 --> 00:23:16,070
but it is not so okay yes ninety-eight

595
00:23:14,630 --> 00:23:17,929
percent this thing that's what my real

596
00:23:16,069 --> 00:23:20,240
speed real speed is about ninety-eight

597
00:23:17,929 --> 00:23:22,370
percent the speed of light yeah so with

598
00:23:20,240 --> 00:23:24,288
it's not like back to the future some

599

00:23:22,369 --> 00:23:27,259
and that's what's being spaghettified in

600
00:23:24,288 --> 00:23:29,388
a big black hole nothing like that no

601
00:23:27,259 --> 00:23:30,798
that's it's just because is it because

602
00:23:29,388 --> 00:23:33,589
it's blue shifting towards us so we

603
00:23:30,798 --> 00:23:36,048
here's to be going faster so it's hard

604
00:23:33,589 --> 00:23:37,638
to differentiate with the with the light

605
00:23:36,048 --> 00:23:40,849
that we're observing or what's going on

606
00:23:37,638 --> 00:23:45,048
with that ah yeah I mean basically you

607
00:23:40,849 --> 00:23:46,579
you see things happen faster than if you

608
00:23:45,048 --> 00:23:48,200
were looking at this at a different

609
00:23:46,579 --> 00:23:50,569
angle say so let's say that this was in

610
00:23:48,200 --> 00:23:53,028
the 90 degrees to us we would see it

611
00:23:50,569 --> 00:23:55,038
moving close to one seat we would see it

612
00:23:53,028 --> 00:23:58,278
at its real speed so it's it's all

613
00:23:55,038 --> 00:23:59,990

dependent on that angle um that makes to

614

00:23:58,278 --> 00:24:02,028

the line of sight and the acceleration

615

00:23:59,990 --> 00:24:03,620

that's causing this what's what's

616

00:24:02,028 --> 00:24:06,019

causing it to go with these speeds is

617

00:24:03,619 --> 00:24:07,879

the rate at which is falling into the

618

00:24:06,019 --> 00:24:11,000

accretion disk and then being ejected

619

00:24:07,880 --> 00:24:12,409

back out again right uh no but if you if

620

00:24:11,000 --> 00:24:18,288

you find out the answer that's another

621

00:24:12,409 --> 00:24:20,450

nature papers alright maybe next time

622

00:24:18,288 --> 00:24:22,308

out okay so there's a really great

623

00:24:20,450 --> 00:24:25,190

animation that helps to show us these

624

00:24:22,308 --> 00:24:28,730

yes yes I'm so let's move on to that and

625

00:24:25,190 --> 00:24:30,590

while Scott's pulling that up the so

626

00:24:28,730 --> 00:24:31,849

these things there are these knots i

627

00:24:30,589 --> 00:24:33,888

mean everybody you should you pointed

628
00:24:31,849 --> 00:24:35,329
them out already are these I what do you

629
00:24:33,888 --> 00:24:38,869
think's causing that what do you think's

630
00:24:35,329 --> 00:24:40,460
causing those features uh I like one of

631
00:24:38,869 --> 00:24:42,168
the other answer because I've been okay

632
00:24:40,460 --> 00:24:45,379
all right how about how about you Marcus

633
00:24:42,169 --> 00:24:47,509
let me get you in on that yeah yes so to

634
00:24:45,378 --> 00:24:49,548
make one of these nodes you need to

635
00:24:47,509 --> 00:24:52,569
increase the activity of the central

636
00:24:49,548 --> 00:24:55,548
source for some time so imagine have a

637
00:24:52,569 --> 00:24:59,329
the black hole producing this outflow

638
00:24:55,548 --> 00:25:01,759
and for some time the input on the black

639
00:24:59,329 --> 00:25:04,298
hole gets higher so the black hole is

640
00:25:01,759 --> 00:25:07,220
gonna dump more material into the jet

641
00:25:04,298 --> 00:25:09,349
then the black hole is going to go box

642
00:25:07,220 --> 00:25:13,190
which initial state and this additional

643
00:25:09,349 --> 00:25:16,788
material will march forward as an entity

644
00:25:13,190 --> 00:25:22,940
that we call a blob haha yes the

645
00:25:16,788 --> 00:25:30,950
technical jargon I may have fun is that

646
00:25:22,940 --> 00:25:32,629
an acronym be today okay so Scott has

647
00:25:30,950 --> 00:25:35,090
the animation up now and here we can

648
00:25:32,628 --> 00:25:37,069
kind of see the blobs as Marcos has

649
00:25:35,089 --> 00:25:43,250
dubbed that's coined that term I used

650
00:25:37,069 --> 00:25:46,069
for the first time oh yeah so here we

651
00:25:43,250 --> 00:25:47,869
can kind of see that so one of the blobs

652
00:25:46,069 --> 00:25:51,648
I think you said it was blob be kind of

653
00:25:47,869 --> 00:25:54,229
smashes into one blob see the one just

654
00:25:51,648 --> 00:25:55,969
downstream so it's more just a lot of it

655
00:25:54,230 --> 00:25:59,149
the one just in front of it is actually

656

00:25:55,970 --> 00:26:00,620
also what we call superluminal or faster

657
00:25:59,148 --> 00:26:03,109
than light it's moving at about two

658
00:26:00,619 --> 00:26:06,259
times the speed of light but because the

659
00:26:03,109 --> 00:26:08,148
other was faster it's a it's it's

660
00:26:06,259 --> 00:26:10,638
colliding with it you know just like a

661
00:26:08,148 --> 00:26:12,378
car wreck so it's a it's not slowing

662
00:26:10,638 --> 00:26:15,038
down so it runs right into the back of

663
00:26:12,378 --> 00:26:17,628
it so that's what you're seeing happen

664
00:26:15,038 --> 00:26:20,329
in the final frame you kind of see how

665
00:26:17,628 --> 00:26:23,778
it becomes one blob and gets bright and

666
00:26:20,329 --> 00:26:25,398
that's that's the collision in action so

667
00:26:23,778 --> 00:26:26,898
I know that we've stopped in 2014 and

668
00:26:25,398 --> 00:26:28,668
that's the last frame we have of this

669
00:26:26,898 --> 00:26:30,288
but do you think it's going to overtake

670
00:26:28,669 --> 00:26:32,090

it or or is it just going to keep

671

00:26:30,288 --> 00:26:34,369

pushing the whole mess forward is it

672

00:26:32,089 --> 00:26:37,189

just gonna now we have super blob

673

00:26:34,369 --> 00:26:38,659

I'll get credit for that now we're kind

674

00:26:37,190 --> 00:26:40,100

of in an uncharted territory so that's

675

00:26:38,660 --> 00:26:41,330

kind of why this was a fake result is

676

00:26:40,099 --> 00:26:43,969

we've never seen anything like this

677

00:26:41,329 --> 00:26:48,439

before but we think it's going to take

678

00:26:43,970 --> 00:26:51,110

about 30 years of our time to for this

679

00:26:48,440 --> 00:26:52,850

to evolve and to see exactly what

680

00:26:51,109 --> 00:26:54,799

happens but what should happen if the

681

00:26:52,849 --> 00:26:57,679

theory is correct is that they should

682

00:26:54,799 --> 00:26:59,720

merge and then move downstream with a

683

00:26:57,680 --> 00:27:01,460

slightly slower speed somewhere in

684

00:26:59,720 --> 00:27:05,390

between the two speeds that they they

685
00:27:01,460 --> 00:27:08,240
initially had and and it'll keep moving

686
00:27:05,390 --> 00:27:12,980
out so so this explains why Roland is

687
00:27:08,240 --> 00:27:16,819
the mission head for W for future

688
00:27:12,980 --> 00:27:19,250
telescope yes yeah we need we need to

689
00:27:16,819 --> 00:27:21,500
continue taking pictures yeah so let me

690
00:27:19,250 --> 00:27:22,849
actually point something out that may

691
00:27:21,500 --> 00:27:25,700
not be immediately obvious when you look

692
00:27:22,849 --> 00:27:27,649
at this so it's actually true in

693
00:27:25,700 --> 00:27:30,440
astronomy that the sort of the natural

694
00:27:27,650 --> 00:27:33,590
timescale for most things to evolve is

695
00:27:30,440 --> 00:27:35,750
very long so of course you know the

696
00:27:33,589 --> 00:27:37,879
earth takes a year to go around the Sun

697
00:27:35,750 --> 00:27:40,339
but most things that we look at you know

698
00:27:37,880 --> 00:27:42,080
other galaxies for example are much

699
00:27:40,339 --> 00:27:44,269
bigger and the timescale sort of scale

700
00:27:42,079 --> 00:27:46,669
with the size of the system so typically

701
00:27:44,269 --> 00:27:48,889
most things change only over scales of

702
00:27:46,670 --> 00:27:50,539
millions of years which means it as a

703
00:27:48,890 --> 00:27:52,700
human if we take a picture and we take

704
00:27:50,539 --> 00:27:55,129
another picture a decade later things

705
00:27:52,700 --> 00:27:56,509
look exactly identical so the fact that

706
00:27:55,130 --> 00:27:57,980
we're actually looking at something here

707
00:27:56,509 --> 00:28:00,829
that actually looks different is

708
00:27:57,980 --> 00:28:03,049
actually quite remarkable and what is

709
00:28:00,829 --> 00:28:04,939
particularly remarkable is that it is

710
00:28:03,049 --> 00:28:07,099
true that you can see things change but

711
00:28:04,940 --> 00:28:09,890
typically they have to be closed by so

712
00:28:07,099 --> 00:28:12,109
most of the measurements like this that

713

00:28:09,890 --> 00:28:14,150
have been done our measurements in our

714
00:28:12,109 --> 00:28:16,339
own Milky Way that's been done already

715
00:28:14,150 --> 00:28:17,780
you know century ago we're very close to

716
00:28:16,339 --> 00:28:20,480
the Sun other stars you can see them

717
00:28:17,779 --> 00:28:22,910
slowly move on the sky with Hubble you

718
00:28:20,480 --> 00:28:24,650
can do such precise measurements that

719
00:28:22,910 --> 00:28:26,269
we've now actually been able to do such

720
00:28:24,650 --> 00:28:29,150
measurements where we see stars moving

721
00:28:26,269 --> 00:28:30,710
for example in our local group so that's

722
00:28:29,150 --> 00:28:32,809
basically still within you know a

723
00:28:30,710 --> 00:28:36,289
million light-years from where we are

724
00:28:32,808 --> 00:28:38,269
now this thing is actually almost you

725
00:28:36,289 --> 00:28:41,329
know a few hundred million light-years

726
00:28:38,269 --> 00:28:42,859
away which means that the only reason we

727
00:28:41,329 --> 00:28:45,259

see something move here is because it's

728

00:28:42,859 --> 00:28:47,389

going so fast it's really going you know

729

00:28:45,259 --> 00:28:48,179

at almost the speed of light it appears

730

00:28:47,390 --> 00:28:50,369

to be going even

731

00:28:48,179 --> 00:28:53,009

faster that's why we can do this so far

732

00:28:50,368 --> 00:28:55,678

away typically you know anything else

733

00:28:53,009 --> 00:28:57,659

that you look at this distance will look

734

00:28:55,679 --> 00:28:58,980

just the same if you look at it now or

735

00:28:57,659 --> 00:29:00,929

you look at it five hundred years from

736

00:28:58,980 --> 00:29:02,368

now so this is actually quite remarkable

737

00:29:00,929 --> 00:29:04,499

that this can be done and it's really

738

00:29:02,368 --> 00:29:06,298

only Hubble that allows you to do this

739

00:29:04,499 --> 00:29:09,058

at this point because you need this very

740

00:29:06,298 --> 00:29:10,918

sharp images and as cal points out you

741

00:29:09,058 --> 00:29:14,278

know if if helpful were to disappear at

742
00:29:10,919 --> 00:29:16,169
some point and you know if NASA or other

743
00:29:14,278 --> 00:29:17,990
space agencies continue to run future

744
00:29:16,169 --> 00:29:20,730
telescopes with similar you know

745
00:29:17,990 --> 00:29:22,710
sharpness of images we will be able to

746
00:29:20,730 --> 00:29:24,240
continue to follow how this evolves over

747
00:29:22,710 --> 00:29:26,340
time which is really a very exciting

748
00:29:24,240 --> 00:29:28,378
prospect so how bright is this stuff in

749
00:29:26,339 --> 00:29:31,470
the infrared because JWST is primarily

750
00:29:28,378 --> 00:29:33,089
infrared 90 w first will be 12 so can

751
00:29:31,470 --> 00:29:35,909
will this be some follow up the

752
00:29:33,089 --> 00:29:38,368
opportunities there or seem to be in the

753
00:29:35,909 --> 00:29:40,559
optical and above no no I mean this is

754
00:29:38,368 --> 00:29:42,058
so this is synchrotron emission which

755
00:29:40,558 --> 00:29:44,460
you don't have to know exactly how that

756
00:29:42,058 --> 00:29:46,980
works but it's a very broad spectrum so

757
00:29:44,460 --> 00:29:50,069
things change slowly as you change

758
00:29:46,980 --> 00:29:52,798
wavelengths so if you have a if you have

759
00:29:50,069 --> 00:29:56,730
HSC resolution but it an infrared band

760
00:29:52,798 --> 00:29:58,319
it should be fine there's there you

761
00:29:56,730 --> 00:29:59,399
can't make me take that to extremes you

762
00:29:58,319 --> 00:30:01,019
wouldn't want to shift all the way up to

763
00:29:59,398 --> 00:30:03,778
x-rays because then you actually might

764
00:30:01,019 --> 00:30:06,778
start probing changes within the jet in

765
00:30:03,778 --> 00:30:08,099
terms of where x-ray emitting portions

766
00:30:06,778 --> 00:30:11,099
are and where the optical is but

767
00:30:08,099 --> 00:30:12,538
infrared is fine good answer well that's

768
00:30:11,099 --> 00:30:14,428
good that definitely that'll be some

769
00:30:12,538 --> 00:30:18,839
follow-up it seems your observations and

770

00:30:14,429 --> 00:30:21,298
so with the blob analogy oh no oh yeah I

771
00:30:18,839 --> 00:30:23,128
began to put up on Twitter so this is ma

772
00:30:21,298 --> 00:30:31,859
is it black hole illuminates ongoing

773
00:30:23,128 --> 00:30:34,528
bombardment and those and for those

774
00:30:31,859 --> 00:30:39,508
planes drinking game accretion disk ok

775
00:30:34,528 --> 00:30:41,970
so we pres we just get a comment in here

776
00:30:39,509 --> 00:30:43,259
real quick from YouTube this is relevant

777
00:30:41,970 --> 00:30:46,288
to what you're just saying about these

778
00:30:43,259 --> 00:30:49,200
stuff the blob smashing into each other

779
00:30:46,288 --> 00:30:50,908
he's asking is there fusion going on in

780
00:30:49,200 --> 00:30:52,230
these particle collisions in other words

781
00:30:50,909 --> 00:30:55,200
are they hitting each other with enough

782
00:30:52,230 --> 00:30:58,889
force to maybe do some to maybe call

783
00:30:55,200 --> 00:31:00,298
some fusion reactions and the so that's

784
00:30:58,888 --> 00:31:01,919

that's a fighting because it's hard to

785

00:31:00,298 --> 00:31:03,660

imagine what the environment

786

00:31:01,920 --> 00:31:05,960

out there is life but the the densities

787

00:31:03,660 --> 00:31:08,009

we're talking about are incredibly low

788

00:31:05,960 --> 00:31:12,150

compared to the kind of densities that

789

00:31:08,009 --> 00:31:17,700

you need for fusion so the answer is no

790

00:31:12,150 --> 00:31:19,200

definitely no oh but but there you know

791

00:31:17,700 --> 00:31:21,150

it's still a very extreme state of

792

00:31:19,200 --> 00:31:23,759

matter if that's any consolation so it's

793

00:31:21,150 --> 00:31:24,960

we're still talking about particles

794

00:31:23,759 --> 00:31:27,539

charged particles that have been

795

00:31:24,960 --> 00:31:29,190

accelerated to have energies up to a te

796

00:31:27,539 --> 00:31:30,809

vea dat tera electron volt so that's

797

00:31:29,190 --> 00:31:34,259

it's very very high we're talking like

798

00:31:30,809 --> 00:31:36,329

you know LHC quantities so okay well

799
00:31:34,259 --> 00:31:38,490
that is that is a consolation thank you

800
00:31:36,329 --> 00:31:39,750
finally feeling in extreme matter at

801
00:31:38,490 --> 00:31:44,609
this point that's all i can think in

802
00:31:39,750 --> 00:31:45,930
terms of now so ok so the lips there was

803
00:31:44,609 --> 00:31:48,269
another question I wanted to get to on

804
00:31:45,930 --> 00:31:52,980
the QA app real quick that I have to

805
00:31:48,269 --> 00:31:58,920
pull up real fast okay this is from okay

806
00:31:52,980 --> 00:32:02,009
hisses from fubar Gorch really Lisa

807
00:31:58,920 --> 00:32:06,480
wasn't spelled the way it meant to so it

808
00:32:02,009 --> 00:32:08,430
could be something else you get flown in

809
00:32:06,480 --> 00:32:10,470
these jets as a whole characterized

810
00:32:08,430 --> 00:32:12,180
without a laminar turbulent are the

811
00:32:10,470 --> 00:32:14,490
block other velocity gradients doesn't

812
00:32:12,180 --> 00:32:15,720
have a vorticity do the rotation of the

813
00:32:14,490 --> 00:32:17,519
accretion disk wow that's a good

814
00:32:15,720 --> 00:32:19,380
question these are very sessions and

815
00:32:17,519 --> 00:32:21,809
this can be studied using observations

816
00:32:19,380 --> 00:32:24,690
other than red shift or proper motion

817
00:32:21,809 --> 00:32:27,119
wow really good foobar door dr. shake

818
00:32:24,690 --> 00:32:29,730
that anybody want to take that I'll let

819
00:32:27,119 --> 00:32:32,339
let one of the others talk about okay

820
00:32:29,730 --> 00:32:33,390
who wants that so start with a you know

821
00:32:32,339 --> 00:32:34,799
we've already talked a little bit about

822
00:32:33,390 --> 00:32:37,230
whether they're laminar or not you know

823
00:32:34,799 --> 00:32:39,690
Marcos was saying that that they you

824
00:32:37,230 --> 00:32:41,730
know that long as the stream of material

825
00:32:39,690 --> 00:32:43,950
going into the black hole is relatively

826
00:32:41,730 --> 00:32:45,210
steady then the stream of the jet will

827

00:32:43,950 --> 00:32:46,769
be kind of steady but if it gets kind of

828
00:32:45,210 --> 00:32:48,509
clumping in any way falling into the

829
00:32:46,769 --> 00:32:50,639
black hole then you get these clumps

830
00:32:48,509 --> 00:32:53,730
going out of work for blobs as we as

831
00:32:50,640 --> 00:32:55,860
we've coined them in this hangout so not

832
00:32:53,730 --> 00:32:57,420
so this one is I can think you could

833
00:32:55,859 --> 00:33:00,359
definitely it's not a laminar flow not

834
00:32:57,420 --> 00:33:01,830
smooth flow right no that's right and

835
00:33:00,359 --> 00:33:04,439
there's another thing that we are

836
00:33:01,829 --> 00:33:07,710
finding is working there not only in

837
00:33:04,440 --> 00:33:10,590
this galaxy by in many days you may have

838
00:33:07,710 --> 00:33:13,350
a fast spine in the flow in the slower

839
00:33:10,589 --> 00:33:15,778
surrounding ship so the inner part of

840
00:33:13,349 --> 00:33:17,939
the jet is faster than the outer part

841
00:33:15,778 --> 00:33:20,398

and there is a gradient there is a

842

00:33:17,940 --> 00:33:22,349
gradient in velocity as you go from the

843

00:33:20,398 --> 00:33:26,518
center of the of the debt from the spine

844

00:33:22,348 --> 00:33:27,718
of the debt to the periphery Wow yeah

845

00:33:26,519 --> 00:33:30,269
and another thing that's may be

846

00:33:27,719 --> 00:33:32,009
interesting to point out is that this is

847

00:33:30,269 --> 00:33:34,378
not actually the first jet for which

848

00:33:32,009 --> 00:33:36,288
Eileen has done these measurements she

849

00:33:34,378 --> 00:33:39,538
previously wrote a paper a few years ago

850

00:33:36,288 --> 00:33:41,190
with some of the same group of people on

851

00:33:39,538 --> 00:33:44,069
another galaxy which is much closer by

852

00:33:41,190 --> 00:33:46,259
but also as a jet that can be seen and

853

00:33:44,069 --> 00:33:48,538
there we actually found that the jet

854

00:33:46,259 --> 00:33:50,338
appears to be wiggling a little so if

855

00:33:48,538 --> 00:33:51,960
you think of it in the analogy of like a

856
00:33:50,338 --> 00:33:53,638
garden hose it's like if you have a

857
00:33:51,960 --> 00:33:55,829
garden hose and you hold it still it'll

858
00:33:53,638 --> 00:33:57,718
just spray a straight jet but if you

859
00:33:55,829 --> 00:34:00,058
sort of wiggle it you'll get something

860
00:33:57,719 --> 00:34:01,440
that sort of goes like a helix and we

861
00:34:00,058 --> 00:34:03,960
actually found some evidence in that

862
00:34:01,440 --> 00:34:05,788
particular galaxy for that so certainly

863
00:34:03,960 --> 00:34:07,769
you know a jet isn't necessarily just a

864
00:34:05,788 --> 00:34:09,898
simple straight thing there might be

865
00:34:07,769 --> 00:34:11,519
other physics going on that we can

866
00:34:09,898 --> 00:34:14,190
actually pro for the observations of

867
00:34:11,519 --> 00:34:15,538
this kind ya know what what what about

868
00:34:14,190 --> 00:34:19,168
the last part of this question cadiz to

869
00:34:15,539 --> 00:34:21,028
be studied using a observations other

870
00:34:19,168 --> 00:34:24,088
than I guess you didn't gather the

871
00:34:21,028 --> 00:34:25,710
redshift or proper motion I guess these

872
00:34:24,088 --> 00:34:27,628
were just basically looking at the blobs

873
00:34:25,710 --> 00:34:29,909
themselves and you corrected you use red

874
00:34:27,628 --> 00:34:30,929
shift to correct it for the speed but

875
00:34:29,909 --> 00:34:33,148
they weren't really used in the

876
00:34:30,929 --> 00:34:35,309
observations themselves right yes

877
00:34:33,148 --> 00:34:39,028
section themselves right okay good

878
00:34:35,309 --> 00:34:41,069
question that was nice okay so uh Dan

879
00:34:39,028 --> 00:34:43,168
Buddha is asking also on the Q&A app is

880
00:34:41,068 --> 00:34:46,918
this the first galaxy of this kind I

881
00:34:43,168 --> 00:34:48,719
he's talking about NGC 3862 itself is

882
00:34:46,918 --> 00:34:51,598
this the first gathered for the first

883
00:34:48,719 --> 00:34:54,269
elliptical galaxy of this kind I know I

884

00:34:51,599 --> 00:34:56,879
would say it's incredibly typical for

885
00:34:54,269 --> 00:34:59,730
this class of source it's very very

886
00:34:56,878 --> 00:35:01,288
often so that's that's a small caveat to

887
00:34:59,730 --> 00:35:04,199
what Roland said earlier which is that

888
00:35:01,289 --> 00:35:06,059
you there is a tendency for some of

889
00:35:04,199 --> 00:35:07,469
these kind of wimpy jets which this one

890
00:35:06,059 --> 00:35:10,619
is actually classified as kind of a

891
00:35:07,469 --> 00:35:12,989
wimpy jet to be in these big massive

892
00:35:10,619 --> 00:35:16,260
elliptical galaxies that are highly

893
00:35:12,989 --> 00:35:18,298
evolved and a bit older but not one

894
00:35:16,260 --> 00:35:19,829
percent so that's just it's a tendency

895
00:35:18,298 --> 00:35:22,588
but not a you know a hundred percent

896
00:35:19,829 --> 00:35:24,359
correlation but in general if you find a

897
00:35:22,588 --> 00:35:25,889
radio Chet that's like this and then you

898
00:35:24,358 --> 00:35:28,230

look at the optical to see what's oh

899

00:35:25,889 --> 00:35:28,969

what host galaxy is it in that's a very

900

00:35:28,230 --> 00:35:31,699

typical host

901

00:35:28,969 --> 00:35:33,529

galaxy okay good your question good

902

00:35:31,699 --> 00:35:35,449

question damn so uh Scott you see

903

00:35:33,530 --> 00:35:38,960

anything on Twitter other than you were

904

00:35:35,449 --> 00:35:43,759

inventing acronyms more than me why

905

00:35:38,960 --> 00:35:45,769

would I only do that um a lot there's

906

00:35:43,760 --> 00:35:47,780

been just a lot of really great activity

907

00:35:45,769 --> 00:35:51,289

what you know retweet and cleaning out

908

00:35:47,780 --> 00:35:55,820

there uh Brian of Magnum which is what's

909

00:35:51,289 --> 00:35:57,590

his Twitter handle but up magnetic he's

910

00:35:55,820 --> 00:35:59,990

down with the espresso shots so it's

911

00:35:57,590 --> 00:36:03,349

okay for doing special shouts never

912

00:35:59,989 --> 00:36:06,889

accretion disk is set on air so i didn't

913
00:36:03,349 --> 00:36:11,530
have some more caffeine everybody yes

914
00:36:06,889 --> 00:36:15,079
absolutely accretion disk ok so the

915
00:36:11,530 --> 00:36:18,109
these so you we mention you i think it

916
00:36:15,079 --> 00:36:20,840
was a think it was Roland who said that

917
00:36:18,108 --> 00:36:24,529
you the time scales of this or 30 years

918
00:36:20,840 --> 00:36:26,300
or so or is it make any sense to do me

919
00:36:24,530 --> 00:36:28,280
any more Hubble observations and then in

920
00:36:26,300 --> 00:36:31,900
the near future or are there any plans

921
00:36:28,280 --> 00:36:34,430
to do that to look back at this thing

922
00:36:31,900 --> 00:36:37,400
yeah hot does it make sense to wait

923
00:36:34,429 --> 00:36:40,539
until some more some more just give us

924
00:36:37,400 --> 00:36:43,070
some time though really you are joking

925
00:36:40,539 --> 00:36:45,050
well so I think if you ask any

926
00:36:43,070 --> 00:36:51,619
astronomer would you like more double

927

00:36:45,050 --> 00:36:54,200

observing time no back on my all the

928

00:36:51,619 --> 00:36:58,880

time actually I've got a little too

929

00:36:54,199 --> 00:37:00,289

addicted to it so but may be a good

930

00:36:58,880 --> 00:37:01,880

thing to point out may be a good thing

931

00:37:00,289 --> 00:37:03,500

to point out because not everyone in the

932

00:37:01,880 --> 00:37:05,599

audience may know how this works but of

933

00:37:03,500 --> 00:37:07,880

course you know Hubble is a telescope

934

00:37:05,599 --> 00:37:09,769

that you know was built by NASA with

935

00:37:07,880 --> 00:37:12,829

collaboration from iza European Space

936

00:37:09,769 --> 00:37:15,230

Agency and pretty much any astronomer on

937

00:37:12,829 --> 00:37:16,969

the world can you know put in a proposal

938

00:37:15,230 --> 00:37:18,800

once a year there is a call for

939

00:37:16,969 --> 00:37:21,319

proposals anyone can propose and say hey

940

00:37:18,800 --> 00:37:23,269

if you give me a few hours or a few days

941

00:37:21,320 --> 00:37:26,088
of time on this telescope I would like

942
00:37:23,269 --> 00:37:27,289
to do X and then once a year there is

943
00:37:26,088 --> 00:37:28,789
this set of committees that comes

944
00:37:27,289 --> 00:37:30,920
together and picks what they consider

945
00:37:28,789 --> 00:37:33,588
you know the best and you know most

946
00:37:30,920 --> 00:37:35,358
meritorious science so it's a

947
00:37:33,588 --> 00:37:37,159
competitive process so obviously we'd

948
00:37:35,358 --> 00:37:38,929
like to keep following you know these

949
00:37:37,159 --> 00:37:40,960
blobs and you know if we get an

950
00:37:38,929 --> 00:37:43,469
observation every week that'd be great

951
00:37:40,960 --> 00:37:45,659
but the bottom line is there's very

952
00:37:43,469 --> 00:37:48,019
strong competition so I think there's a

953
00:37:45,659 --> 00:37:50,699
very good case to keep looking at this

954
00:37:48,019 --> 00:37:52,349
object but of course since the time

955
00:37:50,699 --> 00:37:55,169

scale for it to evolve is you know

956

00:37:52,349 --> 00:37:56,430

decades you know we'd love to look again

957

00:37:55,170 --> 00:37:58,050

next year there's other kinds of

958

00:37:56,429 --> 00:37:59,519

observations we haven't done yet so far

959

00:37:58,050 --> 00:38:01,109

we've done only straight imaging you

960

00:37:59,519 --> 00:38:03,590

know you might think about you know

961

00:38:01,108 --> 00:38:06,239

polarimetry other wave bands whatever

962

00:38:03,590 --> 00:38:07,950

but we'll have to compete and you know

963

00:38:06,239 --> 00:38:09,689

given that it evolves over time scale of

964

00:38:07,949 --> 00:38:11,250

decades you know it's probably hard to

965

00:38:09,690 --> 00:38:13,260

make a case to keep doing it every year

966

00:38:11,250 --> 00:38:17,070

for the next 30 years because that means

967

00:38:13,260 --> 00:38:18,869

their care is not gonna be done yes that

968

00:38:17,070 --> 00:38:20,460

would yep so yeah we've had we actually

969

00:38:18,869 --> 00:38:23,010

had hangouts on what it's like to try

970
00:38:20,460 --> 00:38:26,608
that's what it was one year ago and so

971
00:38:23,010 --> 00:38:29,940
in June the review panel will be back

972
00:38:26,608 --> 00:38:32,279
yes looking at the next round so we're

973
00:38:29,940 --> 00:38:36,750
there showing up in Baltimore pretty

974
00:38:32,280 --> 00:38:39,000
soon yes right and we have asked for for

975
00:38:36,750 --> 00:38:41,070
time to look for you know to get more

976
00:38:39,000 --> 00:38:42,469
observations and just to explain why a

977
00:38:41,070 --> 00:38:44,730
little bit why we would want to do that

978
00:38:42,469 --> 00:38:45,929
um you know you might say well you see

979
00:38:44,730 --> 00:38:47,699
that as colliding is it still

980
00:38:45,929 --> 00:38:49,319
interesting after that and the answer is

981
00:38:47,699 --> 00:38:51,539
it is still interesting because we're

982
00:38:49,320 --> 00:38:53,338
actually seeing is frightening so we see

983
00:38:51,539 --> 00:38:55,320
this not getting brighter and that means

984
00:38:53,338 --> 00:38:57,269
that particles are getting energized and

985
00:38:55,320 --> 00:38:59,430
one of the unknowns in our theories is

986
00:38:57,269 --> 00:39:00,989
how efficient that is so we want to keep

987
00:38:59,429 --> 00:39:04,379
tracking it maybe not every year every

988
00:39:00,989 --> 00:39:06,299
other year to see how much brighter that

989
00:39:04,380 --> 00:39:09,119
not gets over the over this 30-year

990
00:39:06,300 --> 00:39:10,650
timescale I remembered one thing I

991
00:39:09,119 --> 00:39:12,420
wanted to bring that before I go back to

992
00:39:10,650 --> 00:39:16,108
this question from from Ron Smith on

993
00:39:12,420 --> 00:39:18,599
YouTube but the these these these Jets

994
00:39:16,108 --> 00:39:21,539
are kind of sculpted by magnetic fields

995
00:39:18,599 --> 00:39:23,490
and I do do we have a sense of just what

996
00:39:21,539 --> 00:39:24,750
these things might have are they well

997
00:39:23,489 --> 00:39:26,789
let me start with a more basic question

998

00:39:24,750 --> 00:39:28,349
are they would they originate from just

999
00:39:26,789 --> 00:39:30,150
the spin of the black hole itself

1000
00:39:28,349 --> 00:39:32,160
because the accretion disk has charged

1001
00:39:30,150 --> 00:39:34,440
particles in it or do we know a source

1002
00:39:32,159 --> 00:39:36,210
for this magnetic field or how strong it

1003
00:39:34,440 --> 00:39:38,429
is are there any is there anything we

1004
00:39:36,210 --> 00:39:42,990
know about the magnetic fields of black

1005
00:39:38,429 --> 00:39:44,879
holes it is a mystery it's somewhere

1006
00:39:42,989 --> 00:39:46,588
between knowing in a mystery all markers

1007
00:39:44,880 --> 00:39:49,710
probably a good person have answered

1008
00:39:46,588 --> 00:39:51,690
okay Marcos yeah so what we what we

1009
00:39:49,710 --> 00:39:54,599
believe right now is that this magnetic

1010
00:39:51,690 --> 00:39:56,760
field is magnetic field that was carried

1011
00:39:54,599 --> 00:39:57,269
through the act with the accretion disk

1012
00:39:56,760 --> 00:40:00,240

in

1013

00:39:57,269 --> 00:40:02,759

black hole and we have essentially to

1014

00:40:00,239 --> 00:40:05,309

magnetic fields one permeating the black

1015

00:40:02,760 --> 00:40:07,560

hole and the other permeating the

1016

00:40:05,309 --> 00:40:09,269

accretion disk so you can think of the

1017

00:40:07,559 --> 00:40:12,960

magnetic field as a spaghetti structure

1018

00:40:09,269 --> 00:40:15,509

that is orthogonal or at right angles to

1019

00:40:12,960 --> 00:40:19,139

the accretion list so we have this and

1020

00:40:15,510 --> 00:40:21,750

have a spaghetti coming out and this is

1021

00:40:19,139 --> 00:40:24,299

the now that disc is rotating so this

1022

00:40:21,750 --> 00:40:25,980

spaghetti is going to be twisted just

1023

00:40:24,300 --> 00:40:31,740

really complicated and give us this

1024

00:40:25,980 --> 00:40:33,300

helical helical structure in sewing in

1025

00:40:31,739 --> 00:40:34,889

the other a regular Alex Italian

1026

00:40:33,300 --> 00:40:38,039

observed and it has been seen in a few

1027
00:40:34,889 --> 00:40:40,019
more suitcases few more sauce and is it

1028
00:40:38,039 --> 00:40:41,940
due primarily to charged particles and

1029
00:40:40,019 --> 00:40:44,550
then you trika chrétien disk or does it

1030
00:40:41,940 --> 00:40:45,840
come from somewhere else knows you know

1031
00:40:44,550 --> 00:40:49,230
the tourist particle you move but you

1032
00:40:45,840 --> 00:40:51,780
move a tour charge through medium you'll

1033
00:40:49,230 --> 00:40:54,030
get on a magnetic field there like that

1034
00:40:51,780 --> 00:40:55,830
or is that too simple it is because you

1035
00:40:54,030 --> 00:40:57,840
can you can feel the accretion disk as

1036
00:40:55,829 --> 00:41:00,630
plasma which is a collection of charged

1037
00:40:57,840 --> 00:41:02,579
particles right okay alright great so

1038
00:41:00,630 --> 00:41:05,039
and but but as far as anything else

1039
00:41:02,579 --> 00:41:07,679
about it it's still TBD right you just

1040
00:41:05,039 --> 00:41:09,059
gotta figure out tonight right okay so

1041
00:41:07,679 --> 00:41:11,279
Ron Smith is asking an interesting

1042
00:41:09,059 --> 00:41:13,230
question i kind of like to elaborate a

1043
00:41:11,280 --> 00:41:15,420
little more on this he's asking if it's

1044
00:41:13,230 --> 00:41:17,909
an apparent speed this is referring to

1045
00:41:15,420 --> 00:41:20,490
the blobs i guess and the superluminal

1046
00:41:17,909 --> 00:41:22,349
apparent speed how can it catch up and

1047
00:41:20,489 --> 00:41:23,789
crash into the blob there's actually two

1048
00:41:22,349 --> 00:41:26,219
parts of that right there's the fact

1049
00:41:23,789 --> 00:41:27,539
that it's an apparent ease you need and

1050
00:41:26,219 --> 00:41:29,159
then there's the fact that really is

1051
00:41:27,539 --> 00:41:30,929
going faster than the blob ahead of it

1052
00:41:29,159 --> 00:41:34,079
right yeah so the ninety-eight percent

1053
00:41:30,929 --> 00:41:36,389
number is for the the not that appears

1054
00:41:34,079 --> 00:41:37,769
to go seven see I don't know the exact

1055

00:41:36,389 --> 00:41:40,969
number for the other one but it's a

1056
00:41:37,769 --> 00:41:43,679
little slower and the funny thing is

1057
00:41:40,969 --> 00:41:46,019
obviously if you if you take this jet

1058
00:41:43,679 --> 00:41:47,639
and knock it over on its side you would

1059
00:41:46,019 --> 00:41:49,139
still catch up to the other one but it

1060
00:41:47,639 --> 00:41:50,849
would take much longer like three

1061
00:41:49,139 --> 00:41:52,529
hundred years for to evolve so this

1062
00:41:50,849 --> 00:41:54,509
whole member i told you that one of the

1063
00:41:52,530 --> 00:41:56,010
the effects of this optical illusion is

1064
00:41:54,510 --> 00:41:58,890
that everything is sped up we see the

1065
00:41:56,010 --> 00:42:01,200
whole sequence of events very fast so it

1066
00:41:58,889 --> 00:42:03,929
is it's still moving in real speed

1067
00:42:01,199 --> 00:42:05,460
faster than the one in front of it we

1068
00:42:03,929 --> 00:42:07,319
just sort of we're seeing everything

1069
00:42:05,460 --> 00:42:09,780

it's like putting your video on

1070

00:42:07,320 --> 00:42:10,309

fast-forward that makes sense yeah yeah

1071

00:42:09,780 --> 00:42:11,778

that does

1072

00:42:10,309 --> 00:42:13,670

that's right that's a cool effect and

1073

00:42:11,778 --> 00:42:15,798

unfortunately for us as well the impress

1074

00:42:13,670 --> 00:42:18,289

is also asking on YouTube is there a

1075

00:42:15,798 --> 00:42:20,568

relation between the mass of the black

1076

00:42:18,289 --> 00:42:23,778

hole and the presence of these types of

1077

00:42:20,568 --> 00:42:26,478

jets uh that's funny because there's a

1078

00:42:23,778 --> 00:42:30,349

press release for another paper today by

1079

00:42:26,478 --> 00:42:31,728

Mark okoboji that says yes I think

1080

00:42:30,349 --> 00:42:34,430

that's I think that paper came out

1081

00:42:31,728 --> 00:42:36,018

anyway but he there is a there is a

1082

00:42:34,429 --> 00:42:37,399

let's say an argument that that's the

1083

00:42:36,018 --> 00:42:39,919

case I don't know that it's been a

1084
00:42:37,400 --> 00:42:41,838
hundred percent established but but let

1085
00:42:39,920 --> 00:42:42,979
me also add to that that you know we

1086
00:42:41,838 --> 00:42:44,719
mentioned at the beginning of the

1087
00:42:42,978 --> 00:42:46,429
hangout that there is really these two

1088
00:42:44,719 --> 00:42:48,588
types of black holes that we know exists

1089
00:42:46,429 --> 00:42:50,778
in the universe one we call stellar-mass

1090
00:42:48,588 --> 00:42:53,630
black holes and we know they form from

1091
00:42:50,778 --> 00:42:55,309
the evolution of a normal star so a very

1092
00:42:53,630 --> 00:42:57,528
massive start at the end of its lifetime

1093
00:42:55,309 --> 00:42:59,359
will undergo supernova will become a

1094
00:42:57,528 --> 00:43:01,429
black hole and we also know of these

1095
00:42:59,358 --> 00:43:03,170
black holes that are a million or a

1096
00:43:01,429 --> 00:43:05,419
billion times more massive and sit in

1097
00:43:03,170 --> 00:43:07,548
the Centers of galaxies now we do

1098
00:43:05,420 --> 00:43:09,199
actually know that some stellar mass

1099
00:43:07,548 --> 00:43:13,788
black holes or Stella most compact

1100
00:43:09,199 --> 00:43:15,798
objects do have Jets as well so you know

1101
00:43:13,789 --> 00:43:18,920
while the mass may certainly play a role

1102
00:43:15,798 --> 00:43:21,139
in how things you know appear to us or

1103
00:43:18,920 --> 00:43:23,239
you know how prominent to jet maybe it's

1104
00:43:21,139 --> 00:43:25,068
it's certainly not that you can only get

1105
00:43:23,239 --> 00:43:26,599
a jet if you have a black hole above a

1106
00:43:25,068 --> 00:43:29,058
certain mass because we already know

1107
00:43:26,599 --> 00:43:30,859
that we find them in objects whose mass

1108
00:43:29,059 --> 00:43:33,259
is different by as much as a factor of a

1109
00:43:30,858 --> 00:43:34,759
building so plays a role but it's still

1110
00:43:33,259 --> 00:43:36,559
a much more complex for normal and than

1111
00:43:34,759 --> 00:43:38,719
just a mass it's not just a mass that's

1112

00:43:36,559 --> 00:43:40,789
regulating excellent that's a great

1113
00:43:38,719 --> 00:43:43,159
question thanks to me I appreciate that

1114
00:43:40,789 --> 00:43:45,410
okay so let me I think that's all of our

1115
00:43:43,159 --> 00:43:49,818
questions that we had 0 1 0 I got more

1116
00:43:45,409 --> 00:43:52,788
now let's see let me let me see here dan

1117
00:43:49,818 --> 00:43:55,068
Buddha's asking on the Q&A app all all

1118
00:43:52,789 --> 00:43:57,079
the black holes all the black holes at

1119
00:43:55,068 --> 00:43:59,420
one time emit jets or what condition is

1120
00:43:57,079 --> 00:44:01,339
needed for the black holes to emit jets

1121
00:43:59,420 --> 00:44:02,929
and we alluded to that earlier you need

1122
00:44:01,338 --> 00:44:05,599
to be feeding it right it has to have

1123
00:44:02,929 --> 00:44:07,219
material falling in before these Jets

1124
00:44:05,599 --> 00:44:09,829
will appear so that we talked about that

1125
00:44:07,219 --> 00:44:11,749
earlier on uh what does stephen hawking

1126
00:44:09,829 --> 00:44:13,789

have to say about this charles bell is

1127

00:44:11,748 --> 00:44:16,578

asking i don't know we're not babies on

1128

00:44:13,789 --> 00:44:19,189

in our hangout well we can call them up

1129

00:44:16,579 --> 00:44:23,109

yeah it's calling my i don't know don't

1130

00:44:19,188 --> 00:44:23,108

have them on speed dial right Carol yeah

1131

00:44:23,230 --> 00:44:28,699

yeah sorry don't know girl but that's

1132

00:44:25,550 --> 00:44:29,990

you know well maybe we'll try to reach

1133

00:44:28,699 --> 00:44:33,319

him and maybe he'll be on the future

1134

00:44:29,989 --> 00:44:35,449

hang out okay so um duh I have a

1135

00:44:33,320 --> 00:44:38,650

question I ok and I know that you've

1136

00:44:35,449 --> 00:44:44,149

looked at one other example of this um

1137

00:44:38,650 --> 00:44:46,190

but there are many known examples of

1138

00:44:44,150 --> 00:44:48,769

this phenomenon and we just don't know

1139

00:44:46,190 --> 00:44:51,440

the details of the Jets and what they're

1140

00:44:48,769 --> 00:44:54,639

doing so it's possible that many of the

1141
00:44:51,440 --> 00:44:59,420
Jets and ellipticals are we doing this

1142
00:44:54,639 --> 00:45:02,089
yes yeah um so we are only just now able

1143
00:44:59,420 --> 00:45:03,889
partly because of the you know the

1144
00:45:02,090 --> 00:45:05,269
developments of this trauma tree is

1145
00:45:03,889 --> 00:45:08,659
basically the field that allows us to

1146
00:45:05,269 --> 00:45:11,210
align these images very very well so

1147
00:45:08,659 --> 00:45:13,730
we've only kind of got that a set of

1148
00:45:11,210 --> 00:45:15,889
tools on hand plus the long lifetimes of

1149
00:45:13,730 --> 00:45:19,070
Hubble to really start looking at the

1150
00:45:15,889 --> 00:45:22,129
local universe Jets as I call them now

1151
00:45:19,070 --> 00:45:24,410
so there's definitely more cases where

1152
00:45:22,130 --> 00:45:26,030
we want to look and we think well we may

1153
00:45:24,409 --> 00:45:27,980
see something similar or we may not

1154
00:45:26,030 --> 00:45:29,780
that's you know it's it's pure

1155
00:45:27,980 --> 00:45:31,519
phenomenology at this point so we're

1156
00:45:29,780 --> 00:45:33,140
going to look and see if all the Jets do

1157
00:45:31,519 --> 00:45:38,659
something similar to this or if this is

1158
00:45:33,139 --> 00:45:40,309
a really strange outlier so it's it's a

1159
00:45:38,659 --> 00:45:43,399
probably expected that we will find more

1160
00:45:40,309 --> 00:45:46,369
of these another question I had is do

1161
00:45:43,400 --> 00:45:48,110
you have any I mean this is lots of

1162
00:45:46,369 --> 00:45:51,079
observing time or whatever but are there

1163
00:45:48,110 --> 00:45:54,110
are correlations of the brightening in

1164
00:45:51,079 --> 00:45:57,230
other wavelengths that you've seen are

1165
00:45:54,110 --> 00:45:59,960
you seeing some kind of a phenomenon

1166
00:45:57,230 --> 00:46:02,329
that produces x-rays that suggests this

1167
00:45:59,960 --> 00:46:07,030
associated with this matter creating the

1168
00:46:02,329 --> 00:46:09,289
blob or it's different that's them

1169

00:46:07,030 --> 00:46:11,470
that's a good question in fact maybe

1170
00:46:09,289 --> 00:46:14,090
Marcos could say something about the

1171
00:46:11,469 --> 00:46:16,189
sort of internal shock theory that we

1172
00:46:14,090 --> 00:46:20,420
think that this why we think is a big

1173
00:46:16,190 --> 00:46:22,579
results for for wider reasons well the

1174
00:46:20,420 --> 00:46:26,000
first thing one is to say is that you do

1175
00:46:22,579 --> 00:46:28,940
expect this flaring up to be manifested

1176
00:46:26,000 --> 00:46:32,750
in the optical the x-rays with a user

1177
00:46:28,940 --> 00:46:35,450
name yeah you exist yeah so that that's

1178
00:46:32,750 --> 00:46:36,150
one thing the other thing the reason

1179
00:46:35,449 --> 00:46:37,798
that this is very

1180
00:46:36,150 --> 00:46:41,099
interesting is that this collision of

1181
00:46:37,798 --> 00:46:45,298
blogs of components has been theorized

1182
00:46:41,099 --> 00:46:47,818
about 30 years ago and has been used a

1183
00:46:45,298 --> 00:46:50,250

lot in another family of service called

1184

00:46:47,818 --> 00:46:53,009

gamma ray bursts these are these are

1185

00:46:50,250 --> 00:46:56,699

stellar phenomena that in the collapse

1186

00:46:53,010 --> 00:46:59,460

of a stellar system they form a jet that

1187

00:46:56,699 --> 00:47:03,058

lasts for a few seconds and we we

1188

00:46:59,460 --> 00:47:07,079

theorize that the missionary get out of

1189

00:47:03,059 --> 00:47:10,289

this comes from lees colliding colliding

1190

00:47:07,079 --> 00:47:12,750

components but this has never been seen

1191

00:47:10,289 --> 00:47:14,849

never and this is the first time we

1192

00:47:12,750 --> 00:47:17,880

actually see we see two components

1193

00:47:14,849 --> 00:47:20,609

actually colliding that is that is

1194

00:47:17,880 --> 00:47:24,869

honestly the reason this results found

1195

00:47:20,608 --> 00:47:27,869

its way to nature yeah I see I see but

1196

00:47:24,869 --> 00:47:31,380

this is it a massively larger scale

1197

00:47:27,869 --> 00:47:35,338

that's right and the gamma great or

1198
00:47:31,380 --> 00:47:37,318
sources yeah wow that's amazing as you

1199
00:47:35,338 --> 00:47:40,078
say the phenomenon sort of occurs at

1200
00:47:37,318 --> 00:47:42,150
many different scales not just to the

1201
00:47:40,079 --> 00:47:44,160
scale of supermassive black holes but

1202
00:47:42,150 --> 00:47:46,619
all the way down to sell enough that's

1203
00:47:44,159 --> 00:47:48,659
right okay let me just get a little

1204
00:47:46,619 --> 00:47:50,160
clarification from fubar Gord she says

1205
00:47:48,659 --> 00:47:52,348
part of the river for the record my nick

1206
00:47:50,159 --> 00:47:56,159
is the first default variable name fubar

1207
00:47:52,349 --> 00:47:58,920
yeah I knew that followed by the second

1208
00:47:56,159 --> 00:48:00,659
followed by who knows what okay so yes I

1209
00:47:58,920 --> 00:48:02,099
can't you don't look very chic that it's

1210
00:48:00,659 --> 00:48:04,108
also a really good question you asked so

1211
00:48:02,099 --> 00:48:05,818
you know that overcomes any any

1212
00:48:04,108 --> 00:48:08,098
strangeness and your handle for sure

1213
00:48:05,818 --> 00:48:09,568
okay I think I think that's it for this

1214
00:48:08,099 --> 00:48:11,880
week's car do you have any daddy any

1215
00:48:09,568 --> 00:48:14,880
quick any quick the only thing I'm

1216
00:48:11,880 --> 00:48:16,470
saying there is Michael jovens uh what

1217
00:48:14,880 --> 00:48:17,640
about your just think about the the BBQ

1218
00:48:16,469 --> 00:48:24,169
could have like no we have spaghetti

1219
00:48:17,639 --> 00:48:24,170
remember it's a black hole no Barbie

1220
00:48:25,400 --> 00:48:31,019
head coach all right good well I want to

1221
00:48:28,889 --> 00:48:32,519
thank you eileen and rollin and then

1222
00:48:31,019 --> 00:48:33,869
marcos thank you for joining us this is

1223
00:48:32,519 --> 00:48:35,670
excellent work we look forward to

1224
00:48:33,869 --> 00:48:37,289
hearing more from you and Aileen as you

1225
00:48:35,670 --> 00:48:38,338
get more information from these Jets you

1226

00:48:37,289 --> 00:48:40,410
come back and let us know about them

1227
00:48:38,338 --> 00:48:42,989
absolutely all right thank you guys for

1228
00:48:40,409 --> 00:48:47,269
being in our hangout that's it our

1229
00:48:42,989 --> 00:48:47,269
astronomy food and drink channel

1230
00:48:47,730 --> 00:48:57,130
yeah that's right that's right accretion

1231
00:48:51,429 --> 00:48:58,419
disk every campus okay all right so

1232
00:48:57,130 --> 00:48:59,559
that's it for this week though thank you

1233
00:48:58,420 --> 00:49:05,260
all for watching next week we're going

1234
00:48:59,559 --> 00:49:07,299
to be talking about Pluto yeah this non

1235
00:49:05,260 --> 00:49:09,310
planet are doing very strange bizarre

1236
00:49:07,300 --> 00:49:11,560
things Hubble watched it looked at it

1237
00:49:09,309 --> 00:49:13,328
measured it and we are going to show you

1238
00:49:11,559 --> 00:49:15,549
what these moons are doing next week so

1239
00:49:13,329 --> 00:49:18,369
we look forward to seeing you again and

1240
00:49:15,550 --> 00:49:20,140

as on behalf of Carol and Scott guys

1241

00:49:18,369 --> 00:49:23,170

this was another great hangout thank you

1242

00:49:20,139 --> 00:49:25,690

very much and as always thank you keep

1243

00:49:23,170 --> 00:49:28,150

watching and keep us I messed it up as

1244

00:49:25,690 --> 00:49:31,200

always in the keep looking up for

1245

00:49:28,150 --> 00:49:31,200

accretion disks