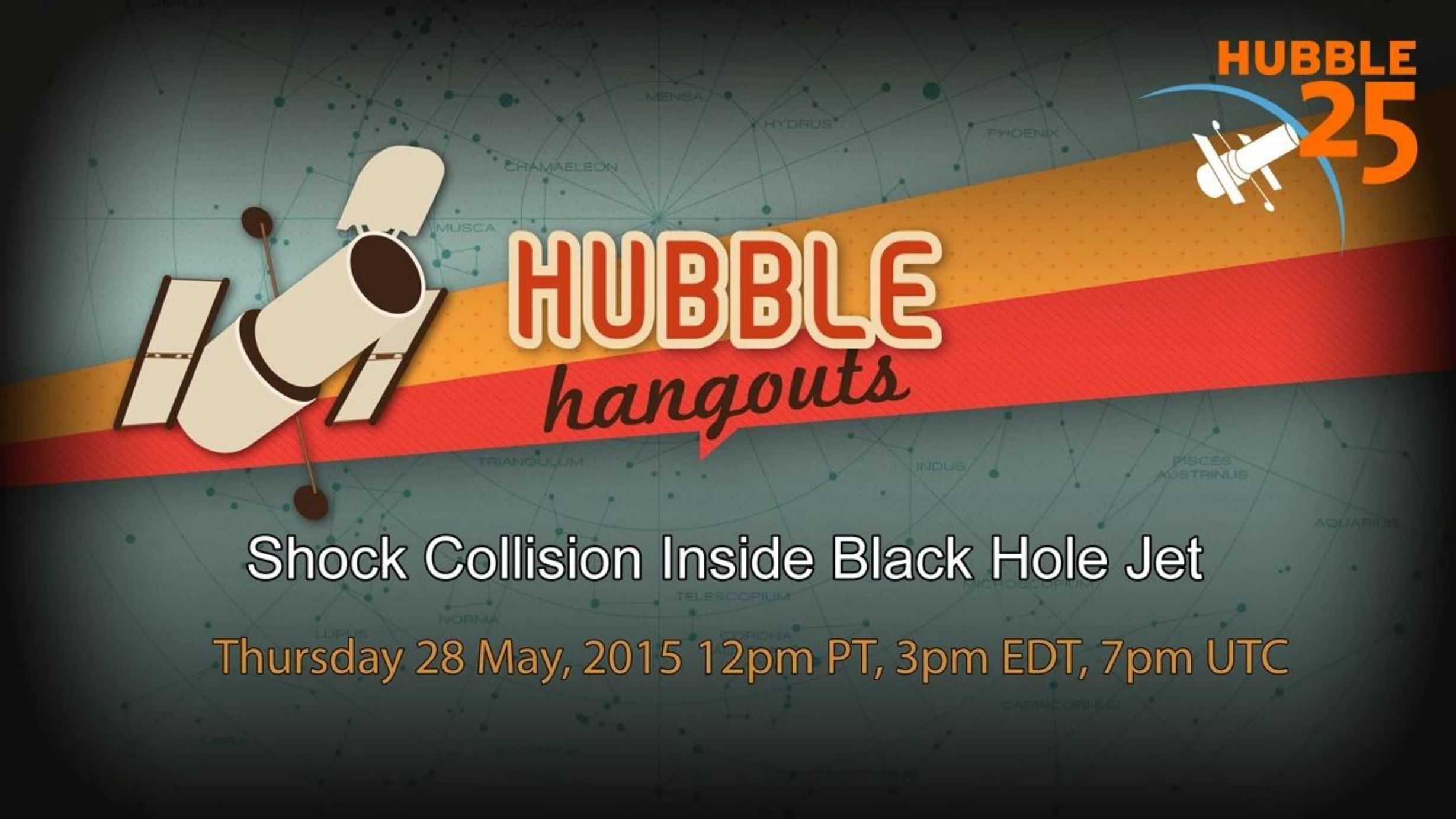
HUBBLE 25
HUBBLE
hangouts
Shock Collision Inside Black Hole Jet
Thursday 28 May, 2015 12pm PT, 3pm EDT, 7pm UTC

1
00:00:08,770 --> 00:00:07,210
hello holders and welcome to this week's

2
00:00:10,690 --> 00:00:08,780
hub will hang out my name is Tony

3
00:00:12,370 --> 00:00:10,700
Darnell I work at the Space Telescope

4
00:00:13,960 --> 00:00:12,380
Science Institute and this week we've

5
00:00:16,209 --> 00:00:13,970
had another really great hangout plan

6
00:00:17,620 --> 00:00:16,219
for you this week astronomers using the

7
00:00:20,580 --> 00:00:17,630
Hubble Space Telescope have been

8
00:00:24,010 --> 00:00:20,590
pointing it at black hole Jets in NGC

9
00:00:25,390 --> 00:00:24,020
3862 a galaxy it is very far away and

10
00:00:27,460 --> 00:00:25,400
that we will learn a lot more about

11
00:00:29,590 --> 00:00:27,470
during the course of this hangout and so

12
00:00:32,019 --> 00:00:29,600
we will be learning about black hole

13
00:00:33,880 --> 00:00:32,029

supermassive black holes by cold Jets as

14
00:00:35,889 --> 00:00:33,890
well as colliding material within those

15
00:00:37,809 --> 00:00:35,899
Jets but before I get started let me

16
00:00:39,910 --> 00:00:37,819
introduce my co-host because this week

17
00:00:41,680 --> 00:00:39,920
we've got a full gang we got everybody

18
00:00:43,299 --> 00:00:41,690
here this week I have with me dr. carol

19
00:00:46,119 --> 00:00:43,309
christian she's the Hubble Space

20
00:00:47,950 --> 00:00:46,129
Telescope every scientist for the hubble

21
00:00:50,770 --> 00:00:47,960
space telescope project from the

22
00:00:52,959 --> 00:00:50,780
Institute and hello Carol and I'm also

23
00:00:55,329 --> 00:00:52,969
with me is Scott Lewis he's driving the

24
00:00:56,949 --> 00:00:55,339
internet how you feeling Scott a much

25
00:01:00,119 --> 00:00:56,959
every language past week you were out

26
00:01:02,829 --> 00:01:00,129
what I missed you guys I'm just miss you

27
00:01:04,149 --> 00:01:02,839
glad you're back I miss you you're glad

28
00:01:06,580 --> 00:01:04,159
if we didn't get what happens you had

29
00:01:07,870 --> 00:01:06,590
pretty much it there's a good reason

30
00:01:11,380 --> 00:01:07,880
we're on opposite sides of the country

31
00:01:12,880 --> 00:01:11,390
to show my spelling yeah so before I

32
00:01:14,770 --> 00:01:12,890
introduce our guest let me just let you

33
00:01:17,140 --> 00:01:14,780
know that we want you to interact with

34
00:01:18,250 --> 00:01:17,150
us in this hangout and you can do that

35
00:01:19,390 --> 00:01:18,260
in a variety of ways which I'm going to

36
00:01:20,860 --> 00:01:19,400
have Scott tell you about in just a

37
00:01:22,540 --> 00:01:20,870
minute but first I want to also remind

38
00:01:25,060 --> 00:01:22,550

you that if you have not followed us on

39
00:01:27,070 --> 00:01:25,070
Twitter we are at Hubble telescope and

40
00:01:28,180 --> 00:01:27,080
you'll be getting all you can get all

41
00:01:30,160 --> 00:01:28,190
the news latest news and information

42
00:01:32,590 --> 00:01:30,170
about these hangouts from there and also

43
00:01:34,060 --> 00:01:32,600
subscribe to our YouTube channel Hubble

44
00:01:35,530 --> 00:01:34,070
site channel and you can also get

45
00:01:37,510 --> 00:01:35,540
notifications from us there we got a lot

46
00:01:39,670 --> 00:01:37,520
of cool stuff on that channel as well so

47
00:01:42,400 --> 00:01:39,680
Scott how can people interact with us

48
00:01:45,310 --> 00:01:42,410
throughout this hangout so the best way

49
00:01:47,890 --> 00:01:45,320
to get in touch with us is using the Q&A

50
00:01:50,050 --> 00:01:47,900
app which is on both YouTube and Google+

51
00:01:52,330 --> 00:01:50,060
so as we're broadcasting right now and

52
00:01:53,380 --> 00:01:52,340
if you're watching it later on you can

53
00:01:54,820 --> 00:01:53,390
stay at the very bottom that we're

54
00:01:56,680 --> 00:01:54,830
answering questions and if you're

55
00:01:58,300 --> 00:01:56,690
watching us live you can put questions

56
00:02:00,850 --> 00:01:58,310
in there will see them up here on our

57
00:02:02,350 --> 00:02:00,860
right hand side and as we respond to

58
00:02:04,480 --> 00:02:02,360
them will put a timestamp on so you can

59
00:02:07,660 --> 00:02:04,490
see when we're applying those specific

60
00:02:10,089 --> 00:02:07,670
questions and also as Tony said that we

61
00:02:13,239 --> 00:02:10,099
are Twitter so I am monitoring both the

62
00:02:13,990 --> 00:02:13,249
hashtag see here hubble 25 and as Tony's

63
00:02:16,870 --> 00:02:14,000

lower third show

64
00:02:18,280 --> 00:02:16,880
is a hashtag hubble hang out and stuff a

65
00:02:19,930 --> 00:02:18,290
monitoring both of those and we'll be

66
00:02:21,940 --> 00:02:19,940
posting some pictures as we're going on

67
00:02:24,280 --> 00:02:21,950
as well as the the links to keep people

68
00:02:26,620 --> 00:02:24,290
and keep all you guys involved in the

69
00:02:27,910 --> 00:02:26,630
conversation all right thanks God now my

70
00:02:29,230 --> 00:02:27,920
favorite way to do it is with the Q&A

71
00:02:30,730 --> 00:02:29,240
app because I have it right here and I

72
00:02:32,590 --> 00:02:30,740
can see you guys right away so that

73
00:02:34,510 --> 00:02:32,600
would be the easiest way so I can

74
00:02:37,330 --> 00:02:34,520
interject the conversation if it's if

75
00:02:40,150 --> 00:02:37,340
it's a timely comment so uh let's get to

76
00:02:42,160 --> 00:02:40,160
today's hangout as I'm anybody who knows

77
00:02:43,660 --> 00:02:42,170
anything about the movement watch these

78
00:02:45,490 --> 00:02:43,670
hangouts for any length of time knows

79
00:02:47,710 --> 00:02:45,500
that the Hubble Space Telescope has been

80
00:02:50,770 --> 00:02:47,720
orbiting above our heads for the last 14

81
00:02:53,440 --> 00:02:50,780
25 years and one of the great advantages

82
00:02:55,750 --> 00:02:53,450
that gives us to Fred for it to have a

83
00:02:58,210 --> 00:02:55,760
telescope up in orbit for so long is

84
00:02:59,740 --> 00:02:58,220
that we can use it to periodically go

85
00:03:01,840 --> 00:02:59,750
back and look at some things that had

86
00:03:04,000 --> 00:03:01,850
looked at before and that's what these

87
00:03:05,890 --> 00:03:04,010
the astronomers we have with us today

88
00:03:08,229 --> 00:03:05,900

have done they have looked at a galaxy

89
00:03:09,370 --> 00:03:08,239
I've already said NGC 3862 which we'll

90
00:03:11,229 --> 00:03:09,380
learn a little bit more about they've

91
00:03:13,510 --> 00:03:11,239
looked at it at four different instances

92
00:03:18,039 --> 00:03:13,520
over the last 20 or so years and have

93
00:03:19,660 --> 00:03:18,049
been able to see features in this a jet

94
00:03:22,270 --> 00:03:19,670
coming from a supermassive black hole

95
00:03:24,460 --> 00:03:22,280
which is unbelievably great i meant the

96
00:03:26,380 --> 00:03:24,470
days of a static universe are clearly

97
00:03:28,870 --> 00:03:26,390
over we can see all kinds of cool things

98
00:03:31,150 --> 00:03:28,880
going on and so with me today is dr.

99
00:03:32,860 --> 00:03:31,160
Eileen Meyer she's she's the leader

100
00:03:35,650 --> 00:03:32,870
author of the paper paper also with me

101
00:03:38,530 --> 00:03:35,660
is dr. Roland van tomorrow and dr.

102
00:03:39,970 --> 00:03:38,540
Marcus georgopoulos there they have all

103
00:03:43,479 --> 00:03:39,980
published a paper which appeared in

104
00:03:44,860 --> 00:03:43,489
today's issue of the journal Nature so

105
00:03:47,319 --> 00:03:44,870
welcome guys and it's good to have you

106
00:03:49,509 --> 00:03:47,329
in our hangout thank you good to be here

107
00:03:50,860 --> 00:03:49,519
thanks Eileen let me start with you a

108
00:03:53,199 --> 00:03:50,870
little bit I want to talk about black

109
00:03:56,020 --> 00:03:53,209
holes first now we've said this before

110
00:03:58,509 --> 00:03:56,030
in previous hangouts but galaxies not

111
00:04:01,240 --> 00:03:58,519
all but most seem to have something

112
00:04:03,340 --> 00:04:01,250
called a supermassive black hole in them

113
00:04:06,430 --> 00:04:03,350

now what is the supermassive black hole

114
00:04:08,890 --> 00:04:06,440
you describe that for us uh yes it's

115
00:04:11,050 --> 00:04:08,900
very roughly somewhere between a million

116
00:04:13,600 --> 00:04:11,060
to a billion times the mass of our Sun

117
00:04:15,970 --> 00:04:13,610
that's a pretty big that's the it's a

118
00:04:17,349 --> 00:04:15,980
big range but it's you know in astronomy

119
00:04:19,719 --> 00:04:17,359
we lot of times deal with order of

120
00:04:21,340 --> 00:04:19,729
magnitude differences so that's that's

121
00:04:23,440 --> 00:04:21,350
sort of the supermassive black hole

122
00:04:27,400 --> 00:04:23,450
category what we call a stellar mass

123
00:04:30,550 --> 00:04:27,410
black hole might only be one time 28

124
00:04:32,080 --> 00:04:30,560
15 times the mass of our Sun there's a

125
00:04:34,660 --> 00:04:32,090
whole range in the middle that's kind of

126
00:04:36,760 --> 00:04:34,670
lumped into intermediate mats so that's

127
00:04:38,170 --> 00:04:36,770
sort of the category we would be

128
00:04:41,170 --> 00:04:38,180
something that might be formed from a

129
00:04:42,520 --> 00:04:41,180
very large super giant explosion or the

130
00:04:44,530 --> 00:04:42,530
death of a supergiant stars right

131
00:04:46,870 --> 00:04:44,540
generates a star exactly now so these

132
00:04:48,520 --> 00:04:46,880
supermassive black holes these are as

133
00:04:52,480 --> 00:04:48,530
you said a million to a billion times

134
00:04:56,080 --> 00:04:52,490
larger and the Sun and most galaxies

135
00:04:57,160 --> 00:04:56,090
seem to have these but you know it do

136
00:04:59,020 --> 00:04:57,170
you think that you're what do you think

137
00:05:01,720 --> 00:04:59,030
causes these things to it to happen is

138
00:05:03,940 --> 00:05:01,730

there any ideas about why they would get

139
00:05:06,760 --> 00:05:03,950
so large or do they happen over time are

140
00:05:10,300 --> 00:05:06,770
they to collate a coalition of a lot of

141
00:05:12,190 --> 00:05:10,310
other black holes are very possibly and

142
00:05:13,660 --> 00:05:12,200
this is one of those things that you

143
00:05:15,310 --> 00:05:13,670
know nature is weirder than our

144
00:05:16,990 --> 00:05:15,320
imaginations I don't think if you went

145
00:05:18,340 --> 00:05:17,000
back to astronomy before we knew about

146
00:05:19,870 --> 00:05:18,350
these things people would have said oh

147
00:05:21,280 --> 00:05:19,880
yeah there's a there's black holes a

148
00:05:23,560 --> 00:05:21,290
billion times the mass of our Sun we

149
00:05:25,810 --> 00:05:23,570
only you know we're trying to understand

150
00:05:27,370 --> 00:05:25,820
that that mystery it's it's a it's one

151
00:05:29,670 --> 00:05:27,380
of the things that's still open so we

152
00:05:32,740 --> 00:05:29,680
know that they grow they get bigger

153
00:05:34,750 --> 00:05:32,750
partly by accreting matter so they form

154
00:05:36,520 --> 00:05:34,760
these big discs of gas and dust that

155
00:05:40,090 --> 00:05:36,530
fall into the black hole so they can

156
00:05:43,570 --> 00:05:40,100
grow that way but we also think we know

157
00:05:45,159 --> 00:05:43,580
that this is not fast enough given the

158
00:05:46,659 --> 00:05:45,169
the lifetime of the universe to grow

159
00:05:50,620 --> 00:05:46,669
these as big as they are so there must

160
00:05:52,720 --> 00:05:50,630
have been some more direct collapse mode

161
00:05:54,400 --> 00:05:52,730
of forming the original seeds for these

162
00:05:56,680 --> 00:05:54,410
black holes but it's a big mystery that

163
00:05:59,260 --> 00:05:56,690

we're trying to figure out now and these

164
00:06:00,430 --> 00:05:59,270
these these Jets these are the ones that

165
00:06:01,900 --> 00:06:00,440
you've been observing and we'll talk

166
00:06:03,460 --> 00:06:01,910
about here in just a little bit do all

167
00:06:04,810 --> 00:06:03,470
black holes have them and and I always

168
00:06:07,030 --> 00:06:04,820
thought that when things fell into a

169
00:06:08,200 --> 00:06:07,040
black hole they kind of disappeared you

170
00:06:09,430 --> 00:06:08,210
couldn't they couldn't come back out

171
00:06:12,250 --> 00:06:09,440
again how can things are coming out of

172
00:06:14,980 --> 00:06:12,260
black holes here uh that's a very good

173
00:06:16,720 --> 00:06:14,990
question and it's it's a bit of an abuse

174
00:06:18,730 --> 00:06:16,730
of the language when we say oh there's

175
00:06:21,040 --> 00:06:18,740
jets from black holes the truth is this

176
00:06:23,530 --> 00:06:21,050
matter never fell in in the terms of

177
00:06:26,230 --> 00:06:23,540
falling past the event horizon so it's

178
00:06:27,940 --> 00:06:26,240
very close and it's probably on in an

179
00:06:30,100 --> 00:06:27,950
accretion disk at first it's kind of

180
00:06:32,200 --> 00:06:30,110
sliding in towards the black hole but

181
00:06:34,000 --> 00:06:32,210
something about the the disk structure

182
00:06:36,279 --> 00:06:34,010
and the black hole structure kicks it

183
00:06:38,680 --> 00:06:36,289
out so it never really falls in in the

184
00:06:40,719 --> 00:06:38,690
first place to answer an earlier

185
00:06:41,140 --> 00:06:40,729
question jets from black holes are

186
00:06:43,300 --> 00:06:41,150
relative

187
00:06:46,690 --> 00:06:43,310
a rare it's only about maybe ten percent

188
00:06:49,300 --> 00:06:46,700

of these objects that give us jets so

189
00:06:52,030 --> 00:06:49,310
only ten percent of all the super so

190
00:06:54,250 --> 00:06:52,040
they would have a jet so and would they

191
00:06:55,750 --> 00:06:54,260
so is its directly am I right in

192
00:06:57,310 --> 00:06:55,760
assuming it's directly related to things

193
00:07:00,160 --> 00:06:57,320
that are falling into the black hole at

194
00:07:02,620 --> 00:07:00,170
the time so if nothing is going in you

195
00:07:04,240 --> 00:07:02,630
don't get a jet that's yeah broadly

196
00:07:08,590 --> 00:07:04,250
speaking that's that's the case so you

197
00:07:10,960 --> 00:07:08,600
can starve a jet of fuel and presumably

198
00:07:13,390 --> 00:07:10,970
it will turn off now Marcos would like

199
00:07:15,700 --> 00:07:13,400
to add something to that I think okay go

200
00:07:17,410 --> 00:07:15,710
ahead Marcos yeah basically you can

201
00:07:19,390 --> 00:07:17,420
start on a black hole if you don't see

202
00:07:23,200 --> 00:07:19,400
the black hole I'm a supermassive black

203
00:07:25,630 --> 00:07:23,210
hole you do not have a quasar it is very

204
00:07:27,700 --> 00:07:25,640
bright point like sources in the center

205
00:07:30,610 --> 00:07:27,710
of galaxies but you still have a black

206
00:07:32,800 --> 00:07:30,620
hole that is just sitting there like the

207
00:07:34,060 --> 00:07:32,810
only having our galactic center right

208
00:07:36,160 --> 00:07:34,070
exactly i was going to say the one in

209
00:07:38,530 --> 00:07:36,170
our galaxy right now is quiet correct so

210
00:07:41,050 --> 00:07:38,540
basically as far as we understand things

211
00:07:44,410 --> 00:07:41,060
every single galaxy has a supermassive

212
00:07:46,210 --> 00:07:44,420
black hole but in most of the galaxies

213
00:07:48,640 --> 00:07:46,220

these black holes are not shed anymore

214
00:07:50,790 --> 00:07:48,650
the period that they were getting food

215
00:07:53,410 --> 00:07:50,800
from the galactic neighborhood is over

216
00:07:55,630 --> 00:07:53,420
so they are not shed and they are not

217
00:07:58,420 --> 00:07:55,640
they are not what we would call a quasar

218
00:08:00,490 --> 00:07:58,430
meaning an accreting black hole and and

219
00:08:02,080 --> 00:08:00,500
also there is no se pega his jet these

220
00:08:07,660 --> 00:08:02,090
jets and quasars are the same thing

221
00:08:10,330 --> 00:08:07,670
right ah well you can not really you can

222
00:08:12,010 --> 00:08:10,340
have quasars that do not produce that

223
00:08:14,350 --> 00:08:12,020
but they still have this very bright

224
00:08:18,100 --> 00:08:14,360
accretion disks that we see in in the

225
00:08:19,540 --> 00:08:18,110
optical and UV and in the x-rays oh so

226
00:08:21,670 --> 00:08:19,550
this is the difference so the difference

227
00:08:23,980 --> 00:08:21,680
is that they will be the quasars d is

228
00:08:25,840 --> 00:08:23,990
the radiating accreting this then from

229
00:08:28,210 --> 00:08:25,850
the black hole that's right so you have

230
00:08:31,000 --> 00:08:28,220
quasars you have quasar that have just

231
00:08:33,280 --> 00:08:31,010
an accretion disk and you have quasars I

232
00:08:36,790 --> 00:08:33,290
have an accretion disk + the Jets coming

233
00:08:41,050 --> 00:08:36,800
out now what makes a difference between

234
00:08:44,230 --> 00:08:41,060
these two families we do not know at

235
00:08:47,680 --> 00:08:44,240
this stage it's not clear what is the

236
00:08:49,270 --> 00:08:47,690
difference and these things look very

237
00:08:51,160 --> 00:08:49,280
similar if you look at them in the

238
00:08:52,780 --> 00:08:51,170

optical will be with a space with a

239
00:08:54,879 --> 00:08:52,790
telescope like the Space Telescope they

240
00:08:57,069 --> 00:08:54,889
look pretty similar those at 58

241
00:08:58,929 --> 00:08:57,079
was that you know and it's a film about

242
00:09:00,699 --> 00:08:58,939
the research to figure out what makes

243
00:09:04,030 --> 00:09:00,709
some of them produce debt and some of

244
00:09:05,229 --> 00:09:04,040
them want to use it okay so let's talk

245
00:09:06,759 --> 00:09:05,239
about the wavelengths a little bit now

246
00:09:08,769 --> 00:09:06,769
you would this was first discovered i

247
00:09:13,269 --> 00:09:08,779
think in ninety this jet was first

248
00:09:14,679 --> 00:09:13,279
discovered in 3862 in 92 i believe and

249
00:09:16,509 --> 00:09:14,689
then and then it was and then it was

250
00:09:20,349 --> 00:09:16,519
observed for the first time by hubble in

251
00:09:22,030 --> 00:09:20,359
94 in the new said it was visible in

252
00:09:23,829 --> 00:09:22,040
optical what are the wavelengths are

253
00:09:27,819 --> 00:09:23,839
these things very bright in on talking

254
00:09:29,799 --> 00:09:27,829
about the Jets themselves it wants to

255
00:09:33,159 --> 00:09:29,809
take that one I'll let me let me call

256
00:09:35,499 --> 00:09:33,169
mr. in a general sense what is happening

257
00:09:37,150 --> 00:09:35,509
with black holes so you have something

258
00:09:39,669 --> 00:09:37,160
that is very small and very massive

259
00:09:42,069 --> 00:09:39,679
sitting in the center of a galaxy and in

260
00:09:45,340 --> 00:09:42,079
fact it's so small that it's a black

261
00:09:48,069 --> 00:09:45,350
hole you have material in the galaxy

262
00:09:50,979 --> 00:09:48,079
stars have stars and gas and dust are

263
00:09:54,999 --> 00:09:50,989

all things you find in galaxies and the

264
00:09:57,099 --> 00:09:55,009
gas has a tendency to you know fall into

265
00:09:58,749 --> 00:09:57,109
the center and when you have a lot of

266
00:10:01,419 --> 00:09:58,759
gas that you try to squeeze in a very

267
00:10:03,159 --> 00:10:01,429
small volume you get friction so the gas

268
00:10:05,499 --> 00:10:03,169
basically as friction with itself and it

269
00:10:07,299 --> 00:10:05,509
gets very hot so what happens in all of

270
00:10:09,970 --> 00:10:07,309
these cases when there is material

271
00:10:12,269 --> 00:10:09,980
falling onto a black hole you have very

272
00:10:14,769 --> 00:10:12,279
hot gas that sits next to it and that

273
00:10:16,539 --> 00:10:14,779
produces radiation and emission that you

274
00:10:18,220 --> 00:10:16,549
can see in various wavelengths so

275
00:10:20,530 --> 00:10:18,230
something that's very conspicuous in all

276
00:10:22,329 --> 00:10:20,540
wavelengths is x-ray emission because

277
00:10:26,559 --> 00:10:22,339
when you have material that gets about a

278
00:10:28,539 --> 00:10:26,569
million degrees its natural wavelengths

279
00:10:31,090 --> 00:10:28,549
in which it radiates is x-ray emission

280
00:10:32,739 --> 00:10:31,100
okay something is that the dominant

281
00:10:36,309 --> 00:10:32,749
wavelength for this then or these Jets

282
00:10:37,509 --> 00:10:36,319
uh not for the Jets necessarily but for

283
00:10:40,569 --> 00:10:37,519
the accretion disk so you're always

284
00:10:42,009 --> 00:10:40,579
repeating the there's many source you

285
00:10:43,090 --> 00:10:42,019
know bright sources going on so you have

286
00:10:44,859 --> 00:10:43,100
the accretion disk and then you also

287
00:10:49,629 --> 00:10:44,869
have the Jets and they have very

288
00:10:52,829 --> 00:10:49,639

distinct wavelength distributions so for

289
00:10:55,960 --> 00:10:52,839
the Jets actually another name for

290
00:10:58,449 --> 00:10:55,970
sources black holes with jets is called

291
00:11:01,299 --> 00:10:58,459
radio loud active galaxies and the

292
00:11:02,710 --> 00:11:01,309
reason we call them radio loud is

293
00:11:05,559 --> 00:11:02,720
because they produce a lot of radio

294
00:11:07,120 --> 00:11:05,569
emission so and that's that's a process

295
00:11:10,690 --> 00:11:07,130
called synchrotron emission

296
00:11:15,010 --> 00:11:10,700
and so probably you would say that the

297
00:11:17,320 --> 00:11:15,020
the dominant emission is is radio in the

298
00:11:20,500 --> 00:11:17,330
sense that that's really the easiest way

299
00:11:23,830 --> 00:11:20,510
to pick up a jet radio loud say it again

300
00:11:27,040 --> 00:11:23,840
radio loud what radio loud active

301
00:11:29,170 --> 00:11:27,050
galaxies electric galaxy yes or if not

302
00:11:34,030 --> 00:11:29,180
not be welcome on a bus I would imagine

303
00:11:37,510 --> 00:11:34,040
okay but they also give you plenty of

304
00:11:40,060 --> 00:11:37,520
optical x-ray UV all the way up to gamma

305
00:11:42,430 --> 00:11:40,070
rays even TV level of mission which is

306
00:11:45,190 --> 00:11:42,440
harder than gamma rays so they're

307
00:11:47,170 --> 00:11:45,200
they're totally multi-wavelength emitter

308
00:11:49,120 --> 00:11:47,180
so you will get the whole entire

309
00:11:50,680 --> 00:11:49,130
spectrum covered and these guys so if

310
00:11:52,990 --> 00:11:50,690
you have you know a suite of instruments

311
00:11:54,160 --> 00:11:53,000
which we do fortunately as astronomers

312
00:11:56,380 --> 00:11:54,170
you can actually take pictures of these

313
00:11:58,060 --> 00:11:56,390

in all kinds of different wavelengths

314
00:11:59,830 --> 00:11:58,070
okay well thanks for the back okay so

315
00:12:01,060 --> 00:11:59,840
that good so now we with that background

316
00:12:02,890 --> 00:12:01,070
folks let's talk about a little bit

317
00:12:04,000 --> 00:12:02,900
about what these guys have done so over

318
00:12:05,590 --> 00:12:04,010
the years Hubble has looked at this

319
00:12:07,180 --> 00:12:05,600
we've talked about it before and Scott

320
00:12:09,280 --> 00:12:07,190
would you mind putting up one of the

321
00:12:11,350 --> 00:12:09,290
graphics that shows the the jet with the

322
00:12:12,820 --> 00:12:11,360
different panels on the side from the

323
00:12:14,500 --> 00:12:12,830
different observations when you get a

324
00:12:15,910 --> 00:12:14,510
chance in and while he's bringing that

325
00:12:18,130 --> 00:12:15,920
up let me talk to me ask you Eileen

326
00:12:20,770 --> 00:12:18,140
describe for us a little bit about your

327
00:12:24,100 --> 00:12:20,780
research and what this paper is is

328
00:12:26,920 --> 00:12:24,110
trying to show us as God has a an image

329
00:12:29,740 --> 00:12:26,930
here of some of the observations right

330
00:12:31,570 --> 00:12:29,750
so going back to something you said at

331
00:12:33,340 --> 00:12:31,580
the beginning we are now at the stage

332
00:12:37,090 --> 00:12:33,350
where Hubble has been up for more than

333
00:12:40,330 --> 00:12:37,100
20 years taking pictures which allows us

334
00:12:42,460 --> 00:12:40,340
to start lining these images of the same

335
00:12:46,390 --> 00:12:42,470
object up and just seeing what's changed

336
00:12:50,140 --> 00:12:46,400
over time and what we found here in this

337
00:12:52,390 --> 00:12:50,150
particular galaxy is that this small jet

338
00:12:54,280 --> 00:12:52,400

coming out it looks here like it's

339
00:12:57,280 --> 00:12:54,290
coming out straight in the plane of the

340
00:12:59,380 --> 00:12:57,290
the sky to the right yes jet is actually

341
00:13:02,200 --> 00:12:59,390
pointed very close to our line of sight

342
00:13:05,490 --> 00:13:02,210
so here's what I do the foul on the left

343
00:13:08,590 --> 00:13:05,500
then is the galaxy basically like a lacy

344
00:13:09,820 --> 00:13:08,600
not gonna from the top right yeah you

345
00:13:11,680 --> 00:13:09,830
can kind of think of it like that

346
00:13:14,050 --> 00:13:11,690
because there's you notice this kind of

347
00:13:17,620 --> 00:13:14,060
grayish disk in the middle this is

348
00:13:20,290 --> 00:13:17,630
actually a very presumably a thin dust

349
00:13:21,010 --> 00:13:20,300
disk that's orbiting around the black

350
00:13:23,650 --> 00:13:21,020
hole

351
00:13:26,470 --> 00:13:23,660
self and we're seeing that face on like

352
00:13:28,600 --> 00:13:26,480
a dinner plate and then the jet is

353
00:13:31,060 --> 00:13:28,610
believed to be almost 90 degrees to this

354
00:13:32,950 --> 00:13:31,070
this face on disk so if that helps you

355
00:13:35,290 --> 00:13:32,960
can kind of now imagine that this jet is

356
00:13:38,680 --> 00:13:35,300
not going to the side it's actually

357
00:13:40,390 --> 00:13:38,690
coming at us just at a slight angle so

358
00:13:42,100 --> 00:13:40,400
that we can kind of still see it see

359
00:13:43,720 --> 00:13:42,110
some of the matter yeah but obviously if

360
00:13:45,070 --> 00:13:43,730
it was tues it you know hundred percent

361
00:13:48,310 --> 00:13:45,080
in our in our face we would just see a

362
00:13:50,530 --> 00:13:48,320
dot so okay so how how far away is this

363
00:13:52,300 --> 00:13:50,540

galaxy this good what are some of the

364
00:13:54,790 --> 00:13:52,310
tell us a little about the galaxy first

365
00:13:58,060 --> 00:13:54,800
then we'll move to the so this is a very

366
00:13:59,620 --> 00:13:58,070
typical environment to see a jet like

367
00:14:01,510 --> 00:13:59,630
this it's it's not a particularly

368
00:14:02,770 --> 00:14:01,520
powerful jet it's actually somewhat low

369
00:14:05,320 --> 00:14:02,780
power compared to the whole population

370
00:14:07,360 --> 00:14:05,330
so it is this is what's called a giant

371
00:14:09,220 --> 00:14:07,370
elliptical galaxy so the stars are quite

372
00:14:11,080 --> 00:14:09,230
smooth in distribution and that's why

373
00:14:14,350 --> 00:14:11,090
you get this kind of smooth halo of

374
00:14:17,050 --> 00:14:14,360
light around the jet that's very typical

375
00:14:18,640 --> 00:14:17,060
this is now you actually said at the

376
00:14:20,710 --> 00:14:18,650
beginning that this is a very faraway

377
00:14:22,180 --> 00:14:20,720
galaxy and it's these are all relative

378
00:14:23,980 --> 00:14:22,190
terms so to an astronomer this is not

379
00:14:26,830 --> 00:14:23,990
far away it's only it's only about 90

380
00:14:29,470 --> 00:14:26,840
megaparsecs so far right of me that's

381
00:14:31,330 --> 00:14:29,480
still the local universe to us so things

382
00:14:33,160 --> 00:14:31,340
things haven't changed much I know but I

383
00:14:38,110 --> 00:14:33,170
hadn't had to work at the store worst

384
00:14:40,000 --> 00:14:38,120
yes yes um yeah so that's that's kind of

385
00:14:42,730 --> 00:14:40,010
the environment right and this is a this

386
00:14:44,590 --> 00:14:42,740
is a large galaxy that's a very old

387
00:14:47,170 --> 00:14:44,600
galaxy if its various political rights

388
00:14:49,300 --> 00:14:47,180

yes so elliptical galaxies as far as

389
00:14:53,350 --> 00:14:49,310
understanding is right now I've gone

390
00:14:56,320 --> 00:14:53,360
through mergers and basically have are

391
00:14:58,330 --> 00:14:56,330
quite old and relaxed and if now kind of

392
00:14:59,770 --> 00:14:58,340
you know mixed up their stars into a

393
00:15:01,510 --> 00:14:59,780
nice little ball if you want to think of

394
00:15:03,310 --> 00:15:01,520
it like that so not the not the

395
00:15:07,090 --> 00:15:03,320
beautiful spiral like we live in but

396
00:15:10,300 --> 00:15:07,100
something much different okay so it's uh

397
00:15:12,280 --> 00:15:10,310
and but but and crucially here there's

398
00:15:15,280 --> 00:15:12,290
got enough material near this black hole

399
00:15:18,370 --> 00:15:15,290
to be feeding you right now right yes

400
00:15:20,230 --> 00:15:18,380
that is apparently the case of course

401
00:15:22,180 --> 00:15:20,240
it's always good to remind people that

402
00:15:23,860 --> 00:15:22,190
we don't have I mean Hubble is amazing

403
00:15:26,950 --> 00:15:23,870
but we don't have the resolution to like

404
00:15:29,290 --> 00:15:26,960
get all the way down and see in fine

405
00:15:32,140 --> 00:15:29,300
detail the accretion disk and in almost

406
00:15:33,370 --> 00:15:32,150
any of these systems that's still that's

407
00:15:34,160 --> 00:15:33,380
still something that you know we're

408
00:15:36,410 --> 00:15:34,170
working on within

409
00:15:38,240 --> 00:15:36,420
mendation okay so so Cara let me ask you

410
00:15:41,030 --> 00:15:38,250
a quick question these these panels on

411
00:15:43,759 --> 00:15:41,040
the left is this all the same um oh can

412
00:15:48,110 --> 00:15:43,769
you put it back on track I now I'm

413
00:15:50,360 --> 00:15:48,120

looking at you I see Scott anyway these

414
00:15:52,879 --> 00:15:50,370
panels on the other right here this is

415
00:15:55,790 --> 00:15:52,889
all it says it so it's all wipsy of what

416
00:15:59,120 --> 00:15:55,800
the wide field camera in this this one f

417
00:16:03,379 --> 00:15:59,130
606 filter um is this all the same

418
00:16:05,269 --> 00:16:03,389
instrument you know so the left is

419
00:16:07,400 --> 00:16:05,279
labeled correctly for that image though

420
00:16:09,350 --> 00:16:07,410
that's just for the galaxy sorry alright

421
00:16:11,389 --> 00:16:09,360
alright yeah cuz that would be

422
00:16:17,360 --> 00:16:11,399
impossible for those of you that know

423
00:16:18,650 --> 00:16:17,370
that 94 um like so the first three of

424
00:16:21,920 --> 00:16:18,660
these images were taken with the

425
00:16:25,430 --> 00:16:21,930
venerable with pic to camera so that's

426
00:16:30,860 --> 00:16:25,440
the first three and then ACS was the the

427
00:16:31,730 --> 00:16:30,870
final epic um so yeah so these are these

428
00:16:33,650 --> 00:16:31,740
are actually mixing different

429
00:16:35,420 --> 00:16:33,660
instruments and slightly different

430
00:16:37,340 --> 00:16:35,430
filters although there as you can see

431
00:16:40,460 --> 00:16:37,350
that we've scaled them to all be roughly

432
00:16:42,019 --> 00:16:40,470
the same wavelength okay I don't know if

433
00:16:44,360 --> 00:16:42,029
it's better to keep with this one or two

434
00:16:45,769 --> 00:16:44,370
go to the the image that Marcos sent us

435
00:16:47,569 --> 00:16:45,779
yesterday i'm not quite sure which is

436
00:16:49,430 --> 00:16:47,579
better the one with all the orange in

437
00:16:52,009 --> 00:16:49,440
its not there might be a better one I

438
00:16:53,660 --> 00:16:52,019

don't know that's a that's a nice one

439
00:16:56,569 --> 00:16:53,670
also because it's a bit more zoomed in

440
00:16:59,090 --> 00:16:56,579
yeah so yeah so getting to the jet

441
00:17:01,370 --> 00:16:59,100
itself we we saw four observations there

442
00:17:03,740 --> 00:17:01,380
over the course of the the past 20 years

443
00:17:06,679 --> 00:17:03,750
where was being is it in remit I

444
00:17:09,199 --> 00:17:06,689
actually have a question and so fast

445
00:17:11,000 --> 00:17:09,209
role in to explain this so we were

446
00:17:13,579 --> 00:17:11,010
talking about elliptical galaxies but

447
00:17:21,890 --> 00:17:13,589
then we have this funny diske thing in

448
00:17:25,250 --> 00:17:21,900
the center so um is is a jet or jet like

449
00:17:27,380 --> 00:17:25,260
features in ellipticals a signature that

450
00:17:30,650 --> 00:17:27,390
there might be more structure than just

451
00:17:32,360 --> 00:17:30,660
smooth elliptical structure or do we

452
00:17:34,159 --> 00:17:32,370
know that there are ellipticals that

453
00:17:35,600 --> 00:17:34,169
have structure that have no jets and

454
00:17:38,630 --> 00:17:35,610
have no black holes or how does that

455
00:17:40,940 --> 00:17:38,640
work I mean I know there's no rule for

456
00:17:43,100 --> 00:17:40,950
every elliptical galaxies but kind of

457
00:17:45,399 --> 00:17:43,110
what's the census of different kinds of

458
00:17:47,549 --> 00:17:45,409
elliptical galaxies and which ones have

459
00:17:50,159 --> 00:17:47,559
black holes and which one

460
00:17:52,560 --> 00:17:50,169
have black holes or jets well so it's a

461
00:17:54,840 --> 00:17:52,570
pretty confusing picture and you know

462
00:17:57,899 --> 00:17:54,850
you basically find other kinds of things

463
00:17:59,940 --> 00:17:57,909

that are not necessarily correlated with

464
00:18:03,210 --> 00:17:59,950
either the type of galaxies or the

465
00:18:05,249 --> 00:18:03,220
orientation of the galaxy the fact that

466
00:18:08,220 --> 00:18:05,259
there is a jet is believed to be

467
00:18:10,560 --> 00:18:08,230
strongly correlated to rotation of the

468
00:18:13,080 --> 00:18:10,570
black hole so black holes have to form

469
00:18:15,119 --> 00:18:13,090
from something from material and most

470
00:18:16,860 --> 00:18:15,129
material in the universe is rotating so

471
00:18:19,019 --> 00:18:16,870
our earth goes around the Sun our Sun is

472
00:18:20,609 --> 00:18:19,029
rotating so whatever it is black hole

473
00:18:22,919 --> 00:18:20,619
forms from has probably had some sense

474
00:18:24,389 --> 00:18:22,929
of rotation to it and that means you end

475
00:18:27,029 --> 00:18:24,399
up with the black hole that as a spin

476
00:18:29,999 --> 00:18:27,039
axis and what tends to happen is that

477
00:18:31,499 --> 00:18:30,009
material comes in sort of an accretion

478
00:18:33,869 --> 00:18:31,509
disk that is perpendicular to this axis

479
00:18:35,399 --> 00:18:33,879
and through some mechanism that we don't

480
00:18:38,399 --> 00:18:35,409
fully understand that presumably

481
00:18:40,230 --> 00:18:38,409
involves magnetic fields some material

482
00:18:42,960 --> 00:18:40,240
gets expelled at very high velocities

483
00:18:44,820 --> 00:18:42,970
along that spin axis and a lot of people

484
00:18:47,249 --> 00:18:44,830
have looked into this question and it

485
00:18:49,019 --> 00:18:47,259
appears that the spin axis of the black

486
00:18:51,629 --> 00:18:49,029
hole or the orientation of the jet is

487
00:18:54,210 --> 00:18:51,639
not in any clearer way correlated with

488
00:18:57,350 --> 00:18:54,220

the orientation of the galaxy or maybe

489
00:19:01,139 --> 00:18:57,360
even the type of the galaxy Wow so a

490
00:19:03,570 --> 00:19:01,149
spiral galaxy galaxies can be active and

491
00:19:05,609 --> 00:19:03,580
they can both of jets and it's not it's

492
00:19:08,480 --> 00:19:05,619
not that this very center is all that

493
00:19:11,190 --> 00:19:08,490
strongly correlated to the grand design

494
00:19:13,259 --> 00:19:11,200
features of the galaxy so in this

495
00:19:15,529 --> 00:19:13,269
particular galaxy we have this

496
00:19:19,859 --> 00:19:15,539
elliptical galaxy and then we have this

497
00:19:23,220 --> 00:19:19,869
diski spinning disk II thing and and the

498
00:19:25,320 --> 00:19:23,230
jet then is somewhat perpendicular to

499
00:19:28,350 --> 00:19:25,330
that so it may be that disc e thing is

500
00:19:30,509 --> 00:19:28,360
actually a little tilted too right yeah

501
00:19:32,580 --> 00:19:30,519
we do we know if the elliptical galaxy

502
00:19:35,039 --> 00:19:32,590
is rotating in the same way or

503
00:19:37,440 --> 00:19:35,049
completely different way or is there are

504
00:19:38,879 --> 00:19:37,450
there any studying spectroscopic studies

505
00:19:40,950 --> 00:19:38,889
of the galaxy itself to know its

506
00:19:42,450 --> 00:19:40,960
rotation I don't know for this

507
00:19:45,450 --> 00:19:42,460
particular galaxy but in general

508
00:19:47,340 --> 00:19:45,460
elliptical galaxies tend to be sort of

509
00:19:49,019 --> 00:19:47,350
the shape of an ellipse taste and sort

510
00:19:52,649 --> 00:19:49,029
of like a flattened football they do

511
00:19:54,840 --> 00:19:52,659
tend in general saying 90% of yeah I'm

512
00:19:56,970 --> 00:19:54,850
to actually rotate in the sense that you

513
00:19:59,070 --> 00:19:56,980

would expect but some fractional

514
00:20:01,379 --> 00:19:59,080
galaxies actually rotate more like a

515
00:20:03,209 --> 00:20:01,389
cigar so they're like cigar shaped

516
00:20:05,639 --> 00:20:03,219
instead of like sort of like a frisbee

517
00:20:07,169 --> 00:20:05,649
so there is some variety until you do

518
00:20:08,579 --> 00:20:07,179
the measurement you can't really tell I

519
00:20:11,009 --> 00:20:08,589
don't know if it's been measured for

520
00:20:14,519 --> 00:20:11,019
this galaxy or no great great thanks

521
00:20:19,079 --> 00:20:14,529
alright so back to the graphics oh yeah

522
00:20:20,999 --> 00:20:19,089
so freaking ok so sorry know that we get

523
00:20:22,759 --> 00:20:21,009
the graphic I wanted to point out

524
00:20:25,049 --> 00:20:22,769
something really funny from Twitter

525
00:20:26,849 --> 00:20:25,059
because we are having some conversation

526
00:20:29,279 --> 00:20:26,859
this from Heather R colada or pillow not

527
00:20:30,959 --> 00:20:29,289
said that she would have a drinking game

528
00:20:39,569 --> 00:20:30,969
where they all do a shot when someone

529
00:20:43,739 --> 00:20:39,579
says accretion disc is coming out I'm

530
00:20:47,849 --> 00:20:43,749
drinking coffee this morning yellow or

531
00:20:49,829 --> 00:20:47,859
an Escrima shot look for that graphic we

532
00:20:51,359 --> 00:20:49,839
were out there which i found i really

533
00:20:53,310 --> 00:20:51,369
like the color and this is wealthy

534
00:20:54,269 --> 00:20:53,320
really able to and in a way that we

535
00:20:57,239 --> 00:20:54,279
haven't all set up so you're actually

536
00:20:59,219 --> 00:20:57,249
able to see the movements over time okay

537
00:21:01,019 --> 00:20:59,229
so I'll have Eileen describe this to us

538
00:21:02,459 --> 00:21:01,029

this is these are the observations there

539
00:21:04,680 --> 00:21:02,469
are some features in here why don't you

540
00:21:06,599 --> 00:21:04,690
describe what we're looking at uh right

541
00:21:08,430 --> 00:21:06,609
so if we start at the very top image

542
00:21:11,639 --> 00:21:08,440
which is how we first saw this jet and

543
00:21:13,409 --> 00:21:11,649
back in 94 so now we've zoomed in and

544
00:21:14,789 --> 00:21:13,419
we've kind of subtracted off the light

545
00:21:17,129 --> 00:21:14,799
from the galaxy just because it makes

546
00:21:19,229 --> 00:21:17,139
things stand out a little better and off

547
00:21:21,419 --> 00:21:19,239
to the left there's a little white cross

548
00:21:23,789 --> 00:21:21,429
might look like a dot to saw you that's

549
00:21:25,440 --> 00:21:23,799
actually where the black hole is and

550
00:21:28,139 --> 00:21:25,450
it's actually very bright at that

551
00:21:30,239 --> 00:21:28,149
location so we also subtracted off the

552
00:21:32,579 --> 00:21:30,249
the light from the core the this is this

553
00:21:34,560 --> 00:21:32,589
black hole also so that we could see the

554
00:21:37,680 --> 00:21:34,570
jet better so that's why that left side

555
00:21:40,079 --> 00:21:37,690
is kind of dark so the jet is coming

556
00:21:43,409 --> 00:21:40,089
from the left rather and moving to the

557
00:21:47,759 --> 00:21:43,419
right and you see 4 knots and these are

558
00:21:51,709 --> 00:21:47,769
creatively naval labeled ABCD and nice

559
00:21:56,430 --> 00:21:51,719
as you will see a blue and back in 96

560
00:22:00,479 --> 00:21:56,440
2000-2014 and very obviously the middle

561
00:22:03,449 --> 00:22:00,489
not here which is not be uh was moving

562
00:22:05,369 --> 00:22:03,459
very very rapidly and we tracked this

563
00:22:07,680 --> 00:22:05,379

the speed and we measured it we found

564
00:22:10,289 --> 00:22:07,690
that it's it appears to be seven times

565
00:22:12,839 --> 00:22:10,299
the speed of light okay what do you mean

566
00:22:15,190 --> 00:22:12,849
appears to be it appears to be because

567
00:22:16,930 --> 00:22:15,200
as we know I hope all of us

568
00:22:19,120 --> 00:22:16,940
I've accepted that nothing moves faster

569
00:22:20,289 --> 00:22:19,130
than the speed of light so that means

570
00:22:22,990 --> 00:22:20,299
that this is actually an optical

571
00:22:24,850 --> 00:22:23,000
illusion this is something that's due to

572
00:22:27,009 --> 00:22:24,860
the Doppler effect it's kind of

573
00:22:29,259 --> 00:22:27,019
analogous to the way sounds get higher

574
00:22:30,580 --> 00:22:29,269
pitched when when like you know an

575
00:22:32,470 --> 00:22:30,590
ambulance or something is coming towards

576
00:22:34,060 --> 00:22:32,480
you same sort of thing happens here

577
00:22:36,279 --> 00:22:34,070
because again remember that this jet is

578
00:22:37,930 --> 00:22:36,289
actually pointed almost directly on our

579
00:22:39,700 --> 00:22:37,940
line of sight right there's a big line

580
00:22:41,680 --> 00:22:39,710
of sight component here and it's moving

581
00:22:45,070 --> 00:22:41,690
at something like ninety-eight percent

582
00:22:47,740 --> 00:22:45,080
the speed of light in real speed and

583
00:22:49,720 --> 00:22:47,750
what happens is as soon as a the light

584
00:22:51,909 --> 00:22:49,730
leaves one of these blobs as its

585
00:22:54,310 --> 00:22:51,919
traveling it literally catches up to its

586
00:22:56,379 --> 00:22:54,320
own light so by the time we observe this

587
00:22:58,360 --> 00:22:56,389
sequence of events on earth the whole

588
00:23:01,899 --> 00:22:58,370

time series is sped up and it looks

589
00:23:04,840 --> 00:23:01,909
faster than it really is so let's say

590
00:23:06,399 --> 00:23:04,850
that again just really clearly yes this

591
00:23:08,769 --> 00:23:06,409
is an effect of the fact that it's

592
00:23:11,169 --> 00:23:08,779
coming towards us yeah it appears to be

593
00:23:14,620 --> 00:23:11,179
going faster than life but don't gives

594
00:23:16,060 --> 00:23:14,630
but it is not so okay yes ninety-eight

595
00:23:17,919 --> 00:23:16,070
percent this thing that's what my real

596
00:23:20,230 --> 00:23:17,929
speed real speed is about ninety-eight

597
00:23:22,360 --> 00:23:20,240
percent the speed of light yeah so with

598
00:23:24,279 --> 00:23:22,370
it's not like back to the future some

599
00:23:27,250 --> 00:23:24,289
and that's what's being spaghettified in

600
00:23:29,379 --> 00:23:27,260
a big black hole nothing like that no

601
00:23:30,789 --> 00:23:29,389
that's it's just because is it because

602
00:23:33,580 --> 00:23:30,799
it's blue shifting towards us so we

603
00:23:36,039 --> 00:23:33,590
here's to be going faster so it's hard

604
00:23:37,629 --> 00:23:36,049
to differentiate with the with the light

605
00:23:40,840 --> 00:23:37,639
that we're observing or what's going on

606
00:23:45,039 --> 00:23:40,850
with that ah yeah I mean basically you

607
00:23:46,570 --> 00:23:45,049
you see things happen faster than if you

608
00:23:48,190 --> 00:23:46,580
were looking at this at a different

609
00:23:50,560 --> 00:23:48,200
angle say so let's say that this was in

610
00:23:53,019 --> 00:23:50,570
the 90 degrees to us we would see it

611
00:23:55,029 --> 00:23:53,029
moving close to one seat we would see it

612
00:23:58,269 --> 00:23:55,039
at its real speed so it's it's all

613
00:23:59,980 --> 00:23:58,279

dependent on that angle um that makes to

614
00:24:02,019 --> 00:23:59,990
the line of sight and the acceleration

615
00:24:03,610 --> 00:24:02,029
that's causing this what's what's

616
00:24:06,009 --> 00:24:03,620
causing it to go with these speeds is

617
00:24:07,870 --> 00:24:06,019
the rate at which is falling into the

618
00:24:10,990 --> 00:24:07,880
accretion disk and then being ejected

619
00:24:12,399 --> 00:24:11,000
back out again right uh no but if you if

620
00:24:18,279 --> 00:24:12,409
you find out the answer that's another

621
00:24:20,440 --> 00:24:18,289
nature papers alright maybe next time

622
00:24:22,299 --> 00:24:20,450
out okay so there's a really great

623
00:24:25,180 --> 00:24:22,309
animation that helps to show us these

624
00:24:28,720 --> 00:24:25,190
yes yes I'm so let's move on to that and

625
00:24:30,580 --> 00:24:28,730
while Scott's pulling that up the so

626
00:24:31,840 --> 00:24:30,590
these things there are these knots i

627
00:24:33,879 --> 00:24:31,850
mean everybody you should you pointed

628
00:24:35,320 --> 00:24:33,889
them out already are these I what do you

629
00:24:38,860 --> 00:24:35,330
think's causing that what do you think's

630
00:24:40,450 --> 00:24:38,870
causing those features uh I like one of

631
00:24:42,159 --> 00:24:40,460
the other answer because I've been okay

632
00:24:45,369 --> 00:24:42,169
all right how about how about you Marcus

633
00:24:47,500 --> 00:24:45,379
let me get you in on that yeah yes so to

634
00:24:49,539 --> 00:24:47,510
make one of these nodes you need to

635
00:24:52,560 --> 00:24:49,549
increase the activity of the central

636
00:24:55,539 --> 00:24:52,570
source for some time so imagine have a

637
00:24:59,320 --> 00:24:55,549
the black hole producing this outflow

638
00:25:01,750 --> 00:24:59,330

and for some time the input on the black

639
00:25:04,289 --> 00:25:01,760
hole gets higher so the black hole is

640
00:25:07,210 --> 00:25:04,299
gonna dump more material into the jet

641
00:25:09,340 --> 00:25:07,220
then the black hole is going to go box

642
00:25:13,180 --> 00:25:09,350
which initial state and this additional

643
00:25:16,779 --> 00:25:13,190
material will march forward as an entity

644
00:25:22,930 --> 00:25:16,789
that we call a blog haha yes the

645
00:25:30,940 --> 00:25:22,940
technical jargon I may have fun is that

646
00:25:32,619 --> 00:25:30,950
an acronym be today okay so Scott has

647
00:25:35,080 --> 00:25:32,629
the animation up now and here we can

648
00:25:37,060 --> 00:25:35,090
kind of see the blobs as Marcos has

649
00:25:43,240 --> 00:25:37,070
dubbed that's coined that term I used

650
00:25:46,060 --> 00:25:43,250
for the first time oh yeah so here we

651
00:25:47,860 --> 00:25:46,070
can kind of see that so one of the blobs

652
00:25:51,639 --> 00:25:47,870
I think you said it was blob be kind of

653
00:25:54,220 --> 00:25:51,649
smashes into one blob see the one just

654
00:25:55,960 --> 00:25:54,230
downstream so it's more just a lot of it

655
00:25:59,139 --> 00:25:55,970
the one just in front of it is actually

656
00:26:00,610 --> 00:25:59,149
also what we call superluminal or faster

657
00:26:03,100 --> 00:26:00,620
than light it's moving at about two

658
00:26:06,250 --> 00:26:03,110
times the speed of light but because the

659
00:26:08,139 --> 00:26:06,260
other was faster it's a it's it's

660
00:26:10,629 --> 00:26:08,149
colliding with it you know just like a

661
00:26:12,369 --> 00:26:10,639
car wreck so it's a it's not slowing

662
00:26:15,029 --> 00:26:12,379
down so it runs right into the back of

663
00:26:17,619 --> 00:26:15,039

it so that's what you're seeing happen

664
00:26:20,320 --> 00:26:17,629
in the final frame you kind of see how

665
00:26:23,769 --> 00:26:20,330
it becomes one blob and gets bright and

666
00:26:25,389 --> 00:26:23,779
that's that's the collision in action so

667
00:26:26,889 --> 00:26:25,399
I know that we've stopped in 2014 and

668
00:26:28,659 --> 00:26:26,899
that's the last frame we have of this

669
00:26:30,279 --> 00:26:28,669
but do you think it's going to overtake

670
00:26:32,080 --> 00:26:30,289
it or or is it just going to keep

671
00:26:34,360 --> 00:26:32,090
pushing the whole mess forward is it

672
00:26:37,180 --> 00:26:34,370
just gonna now we have super blob

673
00:26:38,650 --> 00:26:37,190
I'll get credit for that now we're kind

674
00:26:40,090 --> 00:26:38,660
of in an uncharted territory so that's

675
00:26:41,320 --> 00:26:40,100
kind of why this was a fake result is

676
00:26:43,960 --> 00:26:41,330
we've never seen anything like this

677
00:26:48,430 --> 00:26:43,970
before but we think it's going to take

678
00:26:51,100 --> 00:26:48,440
about 30 years of our time to for this

679
00:26:52,840 --> 00:26:51,110
to evolve and to see exactly what

680
00:26:54,790 --> 00:26:52,850
happens but what should happen if the

681
00:26:57,670 --> 00:26:54,800
theory is correct is that they should

682
00:26:59,710 --> 00:26:57,680
merge and then move downstream with a

683
00:27:01,450 --> 00:26:59,720
slightly slower speed somewhere in

684
00:27:05,380 --> 00:27:01,460
between the two speeds that they they

685
00:27:08,230 --> 00:27:05,390
initially had and and it'll keep moving

686
00:27:12,970 --> 00:27:08,240
out so so this explains why Roland is

687
00:27:16,810 --> 00:27:12,980
the mission head for W for future

688
00:27:19,240 --> 00:27:16,820

telescope yes yeah we need we need to

689
00:27:21,490 --> 00:27:19,250
continue taking pictures yeah so let me

690
00:27:22,840 --> 00:27:21,500
actually point something out that may

691
00:27:25,690 --> 00:27:22,850
not be immediately obvious when you look

692
00:27:27,640 --> 00:27:25,700
at this so it's actually true in

693
00:27:30,430 --> 00:27:27,650
astronomy that the sort of the natural

694
00:27:33,580 --> 00:27:30,440
timescale for most things to evolve is

695
00:27:35,740 --> 00:27:33,590
very long so of course you know the

696
00:27:37,870 --> 00:27:35,750
earth takes a year to go around the Sun

697
00:27:40,330 --> 00:27:37,880
but most things that we look at you know

698
00:27:42,070 --> 00:27:40,340
other galaxies for example are much

699
00:27:44,260 --> 00:27:42,080
bigger and the timescale sort of scale

700
00:27:46,660 --> 00:27:44,270
with the size of the system so typically

701
00:27:48,880 --> 00:27:46,670
most things change only over scales of

702
00:27:50,530 --> 00:27:48,890
millions of years which means it as a

703
00:27:52,690 --> 00:27:50,540
human if we take a picture and we take

704
00:27:55,120 --> 00:27:52,700
another picture a decade later things

705
00:27:56,500 --> 00:27:55,130
look exactly identical so the fact that

706
00:27:57,970 --> 00:27:56,510
we're actually looking at something here

707
00:28:00,820 --> 00:27:57,980
that actually looks different is

708
00:28:03,040 --> 00:28:00,830
actually quite remarkable and what is

709
00:28:04,930 --> 00:28:03,050
particularly remarkable is that it is

710
00:28:07,090 --> 00:28:04,940
true that you can see things change but

711
00:28:09,880 --> 00:28:07,100
typically they have to be closed by so

712
00:28:12,100 --> 00:28:09,890
most of the measurements like this that

713
00:28:14,140 --> 00:28:12,110

have been done our measurements in our

714
00:28:16,330 --> 00:28:14,150
own Milky Way that's been done already

715
00:28:17,770 --> 00:28:16,340
you know century ago we're very close to

716
00:28:20,470 --> 00:28:17,780
the Sun other stars you can see them

717
00:28:22,900 --> 00:28:20,480
slowly move on the sky with Hubble you

718
00:28:24,640 --> 00:28:22,910
can do such precise measurements that

719
00:28:26,260 --> 00:28:24,650
we've now actually been able to do such

720
00:28:29,140 --> 00:28:26,270
measurements where we see stars moving

721
00:28:30,700 --> 00:28:29,150
for example in our local group so that's

722
00:28:32,799 --> 00:28:30,710
basically still within you know a

723
00:28:36,280 --> 00:28:32,809
million light-years from where we are

724
00:28:38,260 --> 00:28:36,290
now this thing is actually almost you

725
00:28:41,320 --> 00:28:38,270
know a few hundred million light-years

726
00:28:42,850 --> 00:28:41,330
away which means that the only reason we

727
00:28:45,250 --> 00:28:42,860
see something move here is because it's

728
00:28:47,380 --> 00:28:45,260
going so fast it's really going you know

729
00:28:48,169 --> 00:28:47,390
at almost the speed of light it appears

730
00:28:50,359 --> 00:28:48,179
to be going even

731
00:28:52,999 --> 00:28:50,369
faster that's why we can do this so far

732
00:28:55,669 --> 00:28:53,009
away typically you know anything else

733
00:28:57,649 --> 00:28:55,679
that you look at this distance will look

734
00:28:58,970 --> 00:28:57,659
just the same if you look at it now or

735
00:29:00,919 --> 00:28:58,980
you look at it five hundred years from

736
00:29:02,359 --> 00:29:00,929
now so this is actually quite remarkable

737
00:29:04,489 --> 00:29:02,369
that this can be done and it's really

738
00:29:06,289 --> 00:29:04,499

only Hubble that allows you to do this

739
00:29:09,049 --> 00:29:06,299
at this point because you need this very

740
00:29:10,909 --> 00:29:09,059
sharp images and as cal points out you

741
00:29:14,269 --> 00:29:10,919
know if if helpful were to disappear at

742
00:29:16,159 --> 00:29:14,279
some point and you know if NASA or other

743
00:29:17,980 --> 00:29:16,169
space agencies continue to run future

744
00:29:20,720 --> 00:29:17,990
telescopes with similar you know

745
00:29:22,700 --> 00:29:20,730
sharpness of images we will be able to

746
00:29:24,230 --> 00:29:22,710
continue to follow how this evolves over

747
00:29:26,330 --> 00:29:24,240
time which is really a very exciting

748
00:29:28,369 --> 00:29:26,340
prospect so how bright is this stuff in

749
00:29:31,460 --> 00:29:28,379
the infrared because JWST is primarily

750
00:29:33,080 --> 00:29:31,470
infrared 90 w first will be 12 so can

751
00:29:35,899 --> 00:29:33,090
will this be some follow up the

752
00:29:38,359 --> 00:29:35,909
opportunities there or seem to be in the

753
00:29:40,549 --> 00:29:38,369
optical and above no no I mean this is

754
00:29:42,049 --> 00:29:40,559
so this is synchrotron emission which

755
00:29:44,450 --> 00:29:42,059
you don't have to know exactly how that

756
00:29:46,970 --> 00:29:44,460
works but it's a very broad spectrum so

757
00:29:50,060 --> 00:29:46,980
things change slowly as you change

758
00:29:52,789 --> 00:29:50,070
wavelengths so if you have a if you have

759
00:29:56,720 --> 00:29:52,799
HSC resolution but it an infrared band

760
00:29:58,310 --> 00:29:56,730
it should be fine there's there you

761
00:29:59,389 --> 00:29:58,320
can't make me take that to extremes you

762
00:30:01,009 --> 00:29:59,399
wouldn't want to shift all the way up to

763
00:30:03,769 --> 00:30:01,019

x-rays because then you actually might

764
00:30:06,769 --> 00:30:03,779
start probing changes within the jet in

765
00:30:08,090 --> 00:30:06,779
terms of where x-ray emitting portions

766
00:30:11,090 --> 00:30:08,100
are and where the optical is but

767
00:30:12,529 --> 00:30:11,100
infrared is fine good answer well that's

768
00:30:14,419 --> 00:30:12,539
good that definitely that'll be some

769
00:30:18,830 --> 00:30:14,429
follow-up it seems your observations and

770
00:30:21,289 --> 00:30:18,840
so with the blob analogy oh no oh yeah I

771
00:30:23,119 --> 00:30:21,299
began to put up on Twitter so this is ma

772
00:30:31,850 --> 00:30:23,129
is it black hole illuminates ongoing

773
00:30:34,519 --> 00:30:31,860
bombardment and those and for those

774
00:30:39,499 --> 00:30:34,529
planes drinking game accretion disk ok

775
00:30:41,960 --> 00:30:39,509
so we pres we just get a comment in here

776
00:30:43,249 --> 00:30:41,970
real quick from YouTube this is relevant

777
00:30:46,279 --> 00:30:43,259
to what you're just saying about these

778
00:30:49,190 --> 00:30:46,289
stuff the blob smashing into each other

779
00:30:50,899 --> 00:30:49,200
he's asking is there fusion going on in

780
00:30:52,220 --> 00:30:50,909
these particle collisions in other words

781
00:30:55,190 --> 00:30:52,230
are they hitting each other with enough

782
00:30:58,879 --> 00:30:55,200
force to maybe do some to maybe call

783
00:31:00,289 --> 00:30:58,889
some fusion reactions and the so that's

784
00:31:01,910 --> 00:31:00,299
that's a fighting because it's hard to

785
00:31:03,650 --> 00:31:01,920
imagine what the environment

786
00:31:05,950 --> 00:31:03,660
out there is life but the the densities

787
00:31:08,000 --> 00:31:05,960
we're talking about are incredibly low

788
00:31:12,140 --> 00:31:08,010

compared to the kind of densities that

789
00:31:17,690 --> 00:31:12,150
you need for fusion so the answer is no

790
00:31:19,190 --> 00:31:17,700
definitely no oh but but there you know

791
00:31:21,140 --> 00:31:19,200
it's still a very extreme state of

792
00:31:23,750 --> 00:31:21,150
matter if that's any consolation so it's

793
00:31:24,950 --> 00:31:23,760
we're still talking about particles

794
00:31:27,530 --> 00:31:24,960
charged particles that have been

795
00:31:29,180 --> 00:31:27,540
accelerated to have energies up to a te

796
00:31:30,800 --> 00:31:29,190
vea dat tera electron volt so that's

797
00:31:34,250 --> 00:31:30,810
it's very very high we're talking like

798
00:31:36,320 --> 00:31:34,260
you know LHC quantities so okay well

799
00:31:38,480 --> 00:31:36,330
that is that is a consolation thank you

800
00:31:39,740 --> 00:31:38,490
finally feeling in extreme matter at

801
00:31:44,600 --> 00:31:39,750
this point that's all i can think in

802
00:31:45,920 --> 00:31:44,610
terms of now so ok so the lips there was

803
00:31:48,260 --> 00:31:45,930
another question I wanted to get to on

804
00:31:52,970 --> 00:31:48,270
the QA app real quick that I have to

805
00:31:58,910 --> 00:31:52,980
pull up real fast okay this is from okay

806
00:32:02,000 --> 00:31:58,920
hisses from fubar Gorch really Lisa

807
00:32:06,470 --> 00:32:02,010
wasn't spelled the way it meant to so it

808
00:32:08,420 --> 00:32:06,480
could be something else you get flown in

809
00:32:10,460 --> 00:32:08,430
these jets as a whole characterized

810
00:32:12,170 --> 00:32:10,470
without a laminar turbulent are the

811
00:32:14,480 --> 00:32:12,180
block other velocity gradients doesn't

812
00:32:15,710 --> 00:32:14,490
have a vorticity do the rotation of the

813
00:32:17,510 --> 00:32:15,720

accretion disk wow that's a good

814
00:32:19,370 --> 00:32:17,520
question these are very sessions and

815
00:32:21,800 --> 00:32:19,380
this can be studied using observations

816
00:32:24,680 --> 00:32:21,810
other than red shift or proper motion

817
00:32:27,110 --> 00:32:24,690
wow really good foobar door dr. shake

818
00:32:29,720 --> 00:32:27,120
that anybody want to take that I'll let

819
00:32:32,330 --> 00:32:29,730
let one of the others talk about okay

820
00:32:33,380 --> 00:32:32,340
who wants that so start with a you know

821
00:32:34,790 --> 00:32:33,390
we've already talked a little bit about

822
00:32:37,220 --> 00:32:34,800
whether they're laminar or not you know

823
00:32:39,680 --> 00:32:37,230
Marcos was saying that that they you

824
00:32:41,720 --> 00:32:39,690
know that long as the stream of material

825
00:32:43,940 --> 00:32:41,730
going into the black hole is relatively

826
00:32:45,200 --> 00:32:43,950
steady then the stream of the jet will

827
00:32:46,760 --> 00:32:45,210
be kind of steady but if it gets kind of

828
00:32:48,500 --> 00:32:46,770
clumping in any way falling into the

829
00:32:50,630 --> 00:32:48,510
black hole then you get these clumps

830
00:32:53,720 --> 00:32:50,640
going out of work for blobs as we as

831
00:32:55,850 --> 00:32:53,730
we've coined them in this hangout so not

832
00:32:57,410 --> 00:32:55,860
so this one is I can think you could

833
00:33:00,350 --> 00:32:57,420
definitely it's not a laminar flow not

834
00:33:01,820 --> 00:33:00,360
smooth flow right no that's right and

835
00:33:04,430 --> 00:33:01,830
there's another thing that we are

836
00:33:07,700 --> 00:33:04,440
finding is working there not only in

837
00:33:10,580 --> 00:33:07,710
this galaxy by in many days you may have

838
00:33:13,340 --> 00:33:10,590

a fast spine in the flow in the slower

839
00:33:15,769 --> 00:33:13,350
surrounding ship so the inner part of

840
00:33:17,930 --> 00:33:15,779
the jet is faster than the outer part

841
00:33:20,389 --> 00:33:17,940
and there is a gradient there is a

842
00:33:22,339 --> 00:33:20,399
gradient in velocity as you go from the

843
00:33:26,509 --> 00:33:22,349
center of the of the debt from the spine

844
00:33:27,709 --> 00:33:26,519
of the debt to the periphery Wow yeah

845
00:33:30,259 --> 00:33:27,719
and another thing that's may be

846
00:33:31,999 --> 00:33:30,269
interesting to point out is that this is

847
00:33:34,369 --> 00:33:32,009
not actually the first jet for which

848
00:33:36,279 --> 00:33:34,379
Eileen has done these measurements she

849
00:33:39,529 --> 00:33:36,289
previously wrote a paper a few years ago

850
00:33:41,180 --> 00:33:39,539
with some of the same group of people on

851
00:33:44,060 --> 00:33:41,190
another galaxy which is much closer by

852
00:33:46,249 --> 00:33:44,070
but also as a jet that can be seen and

853
00:33:48,529 --> 00:33:46,259
there we actually found that the jet

854
00:33:50,329 --> 00:33:48,539
appears to be wiggling a little so if

855
00:33:51,950 --> 00:33:50,339
you think of it in the analogy of like a

856
00:33:53,629 --> 00:33:51,960
garden hose it's like if you have a

857
00:33:55,820 --> 00:33:53,639
garden hose and you hold it still it'll

858
00:33:57,709 --> 00:33:55,830
just spray a straight jet but if you

859
00:34:00,049 --> 00:33:57,719
sort of wiggle it you'll get something

860
00:34:01,430 --> 00:34:00,059
that sort of goes like a helix and we

861
00:34:03,950 --> 00:34:01,440
actually found some evidence in that

862
00:34:05,779 --> 00:34:03,960
particular galaxy for that so certainly

863
00:34:07,759 --> 00:34:05,789

you know a jet isn't necessarily just a

864
00:34:09,889 --> 00:34:07,769
simple straight thing there might be

865
00:34:11,510 --> 00:34:09,899
other physics going on that we can

866
00:34:14,180 --> 00:34:11,520
actually pro for the observations of

867
00:34:15,529 --> 00:34:14,190
this kind ya know what what what about

868
00:34:19,159 --> 00:34:15,539
the last part of this question cadiz to

869
00:34:21,019 --> 00:34:19,169
be studied using a observations other

870
00:34:24,079 --> 00:34:21,029
than I guess you didn't gather the

871
00:34:25,700 --> 00:34:24,089
redshift or proper motion I guess these

872
00:34:27,619 --> 00:34:25,710
were just basically looking at the blobs

873
00:34:29,899 --> 00:34:27,629
themselves and you corrected you use red

874
00:34:30,919 --> 00:34:29,909
shift to correct it for the speed but

875
00:34:33,139 --> 00:34:30,929
they weren't really used in the

876
00:34:35,299 --> 00:34:33,149
observations themselves right yes

877
00:34:39,019 --> 00:34:35,309
section themselves right okay good

878
00:34:41,059 --> 00:34:39,029
question that was nice okay so uh Dan

879
00:34:43,159 --> 00:34:41,069
Buddha is asking also on the Q&A app is

880
00:34:46,909 --> 00:34:43,169
this the first galaxy of this kind I

881
00:34:48,710 --> 00:34:46,919
he's talking about NGC 3862 itself is

882
00:34:51,589 --> 00:34:48,720
this the first gathered for the first

883
00:34:54,260 --> 00:34:51,599
elliptical galaxy of this kind I know I

884
00:34:56,869 --> 00:34:54,270
would say it's incredibly typical for

885
00:34:59,720 --> 00:34:56,879
this class of source it's very very

886
00:35:01,279 --> 00:34:59,730
often so that's that's a small caveat to

887
00:35:04,190 --> 00:35:01,289
what Roland said earlier which is that

888
00:35:06,049 --> 00:35:04,200

you there is a tendency for some of

889
00:35:07,460 --> 00:35:06,059
these kind of wimpy jets which this one

890
00:35:10,609 --> 00:35:07,470
is actually classified as kind of a

891
00:35:12,980 --> 00:35:10,619
wimpy jet to be in these big massive

892
00:35:16,250 --> 00:35:12,990
elliptical galaxies that are highly

893
00:35:18,289 --> 00:35:16,260
evolved and a bit older but not one

894
00:35:19,819 --> 00:35:18,299
percent so that's just it's a tendency

895
00:35:22,579 --> 00:35:19,829
but not a you know a hundred percent

896
00:35:24,349 --> 00:35:22,589
correlation but in general if you find a

897
00:35:25,880 --> 00:35:24,359
radio Chet that's like this and then you

898
00:35:28,220 --> 00:35:25,890
look at the optical to see what's oh

899
00:35:28,960 --> 00:35:28,230
what host galaxy is it in that's a very

900
00:35:31,690 --> 00:35:28,970
typical host

901
00:35:33,520 --> 00:35:31,700
galaxy okay good your question good

902
00:35:35,440 --> 00:35:33,530
question damn so uh Scott you see

903
00:35:38,950 --> 00:35:35,450
anything on Twitter other than you were

904
00:35:43,750 --> 00:35:38,960
inventing acronyms more than me why

905
00:35:45,760 --> 00:35:43,760
would I only do that um a lot there's

906
00:35:47,770 --> 00:35:45,770
been just a lot of really great activity

907
00:35:51,280 --> 00:35:47,780
what you know retweet and cleaning out

908
00:35:55,810 --> 00:35:51,290
there uh Brian of Magnum which is what's

909
00:35:57,580 --> 00:35:55,820
his Twitter handle but up magnetic he's

910
00:35:59,980 --> 00:35:57,590
down with the espresso shots so it's

911
00:36:03,339 --> 00:35:59,990
okay for doing special shouts never

912
00:36:06,880 --> 00:36:03,349
accretion disk is set on air so i didn't

913
00:36:11,520 --> 00:36:06,890

have some more caffeine everybody yes

914
00:36:15,070 --> 00:36:11,530
absolutely accretion disk ok so the

915
00:36:18,099 --> 00:36:15,080
these so you we mention you i think it

916
00:36:20,830 --> 00:36:18,109
was a think it was Roland who said that

917
00:36:24,520 --> 00:36:20,840
you the time scales of this or 30 years

918
00:36:26,290 --> 00:36:24,530
or so or is it make any sense to do me

919
00:36:28,270 --> 00:36:26,300
any more Hubble observations and then in

920
00:36:31,890 --> 00:36:28,280
the near future or are there any plans

921
00:36:34,420 --> 00:36:31,900
to do that to look back at this thing

922
00:36:37,390 --> 00:36:34,430
yeah hot does it make sense to wait

923
00:36:40,530 --> 00:36:37,400
until some more some more just give us

924
00:36:43,060 --> 00:36:40,540
some time though really you are joking

925
00:36:45,040 --> 00:36:43,070
well so I think if you ask any

926
00:36:51,609 --> 00:36:45,050
astronomer would you like more double

927
00:36:54,190 --> 00:36:51,619
observing time no back on my all the

928
00:36:58,870 --> 00:36:54,200
time actually I've got a little too

929
00:37:00,280 --> 00:36:58,880
addicted to it so but may be a good

930
00:37:01,870 --> 00:37:00,290
thing to point out may be a good thing

931
00:37:03,490 --> 00:37:01,880
to point out because not everyone in the

932
00:37:05,589 --> 00:37:03,500
audience may know how this works but of

933
00:37:07,870 --> 00:37:05,599
course you know Hubble is a telescope

934
00:37:09,760 --> 00:37:07,880
that you know was built by NASA with

935
00:37:12,820 --> 00:37:09,770
collaboration from iza European Space

936
00:37:15,220 --> 00:37:12,830
Agency and pretty much any astronomer on

937
00:37:16,960 --> 00:37:15,230
the world can you know put in a proposal

938
00:37:18,790 --> 00:37:16,970

once a year there is a call for

939
00:37:21,310 --> 00:37:18,800
proposals anyone can propose and say hey

940
00:37:23,260 --> 00:37:21,320
if you give me a few hours or a few days

941
00:37:26,079 --> 00:37:23,270
of time on this telescope I would like

942
00:37:27,280 --> 00:37:26,089
to do X and then once a year there is

943
00:37:28,780 --> 00:37:27,290
this set of committees that comes

944
00:37:30,910 --> 00:37:28,790
together and picks what they consider

945
00:37:33,579 --> 00:37:30,920
you know the best and you know most

946
00:37:35,349 --> 00:37:33,589
meritorious science so it's a

947
00:37:37,150 --> 00:37:35,359
competitive process so obviously we'd

948
00:37:38,920 --> 00:37:37,160
like to keep following you know these

949
00:37:40,950 --> 00:37:38,930
blobs and you know if we get an

950
00:37:43,460 --> 00:37:40,960
observation every week that'd be great

951
00:37:45,650 --> 00:37:43,470
but the bottom line is there's very

952
00:37:48,010 --> 00:37:45,660
strong competition so I think there's a

953
00:37:50,690 --> 00:37:48,020
very good case to keep looking at this

954
00:37:52,339 --> 00:37:50,700
object but of course since the time

955
00:37:55,160 --> 00:37:52,349
scale for it to evolve is you know

956
00:37:56,420 --> 00:37:55,170
decades you know we'd love to look again

957
00:37:58,040 --> 00:37:56,430
next year there's other kinds of

958
00:37:59,510 --> 00:37:58,050
observations we haven't done yet so far

959
00:38:01,099 --> 00:37:59,520
we've done only straight imaging you

960
00:38:03,580 --> 00:38:01,109
know you might think about you know

961
00:38:06,230 --> 00:38:03,590
polarimetry other wave bands whatever

962
00:38:07,940 --> 00:38:06,240
but we'll have to compete and you know

963
00:38:09,680 --> 00:38:07,950

given that it evolves over time scale of

964
00:38:11,240 --> 00:38:09,690
decades you know it's probably hard to

965
00:38:13,250 --> 00:38:11,250
make a case to keep doing it every year

966
00:38:17,060 --> 00:38:13,260
for the next 30 years because that means

967
00:38:18,859 --> 00:38:17,070
their care is not gonna be done yes that

968
00:38:20,450 --> 00:38:18,869
would yep so yeah we've had we actually

969
00:38:23,000 --> 00:38:20,460
had hangouts on what it's like to try

970
00:38:26,599 --> 00:38:23,010
that's what it was one year ago and so

971
00:38:29,930 --> 00:38:26,609
in June the review panel will be back

972
00:38:32,270 --> 00:38:29,940
yes looking at the next round so we're

973
00:38:36,740 --> 00:38:32,280
there showing up in Baltimore pretty

974
00:38:38,990 --> 00:38:36,750
soon yes right and we have asked for for

975
00:38:41,060 --> 00:38:39,000
time to look for you know to get more

976
00:38:42,460 --> 00:38:41,070
observations and just to explain why a

977
00:38:44,720 --> 00:38:42,470
little bit why we would want to do that

978
00:38:45,920 --> 00:38:44,730
um you know you might say well you see

979
00:38:47,690 --> 00:38:45,930
that as colliding is it still

980
00:38:49,310 --> 00:38:47,700
interesting after that and the answer is

981
00:38:51,530 --> 00:38:49,320
it is still interesting because we're

982
00:38:53,329 --> 00:38:51,540
actually seeing is frightening so we see

983
00:38:55,310 --> 00:38:53,339
this not getting brighter and that means

984
00:38:57,260 --> 00:38:55,320
that particles are getting energized and

985
00:38:59,420 --> 00:38:57,270
one of the unknowns in our theories is

986
00:39:00,980 --> 00:38:59,430
how efficient that is so we want to keep

987
00:39:04,370 --> 00:39:00,990
tracking it maybe not every year every

988
00:39:06,290 --> 00:39:04,380

other year to see how much brighter that

989
00:39:09,109 --> 00:39:06,300
not gets over the over this 30-year

990
00:39:10,640 --> 00:39:09,119
timescale I remembered one thing I

991
00:39:12,410 --> 00:39:10,650
wanted to bring that before I go back to

992
00:39:16,099 --> 00:39:12,420
this question from from Ron Smith on

993
00:39:18,589 --> 00:39:16,109
YouTube but the these these these Jets

994
00:39:21,530 --> 00:39:18,599
are kind of sculpted by magnetic fields

995
00:39:23,480 --> 00:39:21,540
and I do do we have a sense of just what

996
00:39:24,740 --> 00:39:23,490
these things might have are they well

997
00:39:26,780 --> 00:39:24,750
let me start with a more basic question

998
00:39:28,339 --> 00:39:26,790
are they would they originate from just

999
00:39:30,140 --> 00:39:28,349
the spin of the black hole itself

1000
00:39:32,150 --> 00:39:30,150
because the accretion disk has charged

1001
00:39:34,430 --> 00:39:32,160
particles in it or do we know a source

1002
00:39:36,200 --> 00:39:34,440
for this magnetic field or how strong it

1003
00:39:38,420 --> 00:39:36,210
is are there any is there anything we

1004
00:39:42,980 --> 00:39:38,430
know about the magnetic fields of black

1005
00:39:44,870 --> 00:39:42,990
holes it is a mystery it's somewhere

1006
00:39:46,579 --> 00:39:44,880
between knowing in a mystery all markers

1007
00:39:49,700 --> 00:39:46,589
probably a good person have answered

1008
00:39:51,680 --> 00:39:49,710
okay Marcos yeah so what we what we

1009
00:39:54,589 --> 00:39:51,690
believe right now is that this magnetic

1010
00:39:56,750 --> 00:39:54,599
field is magnetic field that was carried

1011
00:39:57,260 --> 00:39:56,760
through the act with the accretion disk

1012
00:40:00,230 --> 00:39:57,270
in

1013
00:40:02,750 --> 00:40:00,240

black hole and we have essentially to

1014
00:40:05,300 --> 00:40:02,760
magnetic fields one permeating the black

1015
00:40:07,550 --> 00:40:05,310
hole and the other permeating the

1016
00:40:09,260 --> 00:40:07,560
accretion disk so you can think of the

1017
00:40:12,950 --> 00:40:09,270
magnetic field as a spaghetti structure

1018
00:40:15,500 --> 00:40:12,960
that is orthogonal or at right angles to

1019
00:40:19,130 --> 00:40:15,510
the accretion list so we have this and

1020
00:40:21,740 --> 00:40:19,140
have a spaghetti coming out and this is

1021
00:40:24,290 --> 00:40:21,750
the now that disc is rotating so this

1022
00:40:25,970 --> 00:40:24,300
spaghetti is going to be twisted just

1023
00:40:31,730 --> 00:40:25,980
really complicated and give us this

1024
00:40:33,290 --> 00:40:31,740
helical helical structure in sewing in

1025
00:40:34,880 --> 00:40:33,300
the other a regular Alex Italian

1026
00:40:38,030 --> 00:40:34,890
observed and it has been seen in a few

1027
00:40:40,010 --> 00:40:38,040
more suitcases few more sauce and is it

1028
00:40:41,930 --> 00:40:40,020
due primarily to charged particles and

1029
00:40:44,540 --> 00:40:41,940
then you trika chrétien disk or does it

1030
00:40:45,830 --> 00:40:44,550
come from somewhere else knows you know

1031
00:40:49,220 --> 00:40:45,840
the tourist particle you move but you

1032
00:40:51,770 --> 00:40:49,230
move a tour charge through medium you'll

1033
00:40:54,020 --> 00:40:51,780
get on a magnetic field there like that

1034
00:40:55,820 --> 00:40:54,030
or is that too simple it is because you

1035
00:40:57,830 --> 00:40:55,830
can you can feel the accretion disk as

1036
00:41:00,620 --> 00:40:57,840
plasma which is a collection of charged

1037
00:41:02,570 --> 00:41:00,630
particles right okay alright great so

1038
00:41:05,030 --> 00:41:02,580

and but but as far as anything else

1039
00:41:07,670 --> 00:41:05,040
about it it's still TBD right you just

1040
00:41:09,050 --> 00:41:07,680
gotta figure out tonight right okay so

1041
00:41:11,270 --> 00:41:09,060
Ron Smith is asking an interesting

1042
00:41:13,220 --> 00:41:11,280
question i kind of like to elaborate a

1043
00:41:15,410 --> 00:41:13,230
little more on this he's asking if it's

1044
00:41:17,900 --> 00:41:15,420
an apparent speed this is referring to

1045
00:41:20,480 --> 00:41:17,910
the blobs i guess and the superluminal

1046
00:41:22,340 --> 00:41:20,490
apparent speed how can it catch up and

1047
00:41:23,780 --> 00:41:22,350
crash into the blob there's actually two

1048
00:41:26,210 --> 00:41:23,790
parts of that right there's the fact

1049
00:41:27,530 --> 00:41:26,220
that it's an apparent ease you need and

1050
00:41:29,150 --> 00:41:27,540
then there's the fact that really is

1051
00:41:30,920 --> 00:41:29,160
going faster than the blob ahead of it

1052
00:41:34,070 --> 00:41:30,930
right yeah so the ninety-eight percent

1053
00:41:36,380 --> 00:41:34,080
number is for the the not that appears

1054
00:41:37,760 --> 00:41:36,390
to go seven see I don't know the exact

1055
00:41:40,960 --> 00:41:37,770
number for the other one but it's a

1056
00:41:43,670 --> 00:41:40,970
little slower and the funny thing is

1057
00:41:46,010 --> 00:41:43,680
obviously if you if you take this jet

1058
00:41:47,630 --> 00:41:46,020
and knock it over on its side you would

1059
00:41:49,130 --> 00:41:47,640
still catch up to the other one but it

1060
00:41:50,840 --> 00:41:49,140
would take much longer like three

1061
00:41:52,520 --> 00:41:50,850
hundred years for to evolve so this

1062
00:41:54,500 --> 00:41:52,530
whole member i told you that one of the

1063
00:41:56,000 --> 00:41:54,510

the effects of this optical illusion is

1064
00:41:58,880 --> 00:41:56,010
that everything is sped up we see the

1065
00:42:01,190 --> 00:41:58,890
whole sequence of events very fast so it

1066
00:42:03,920 --> 00:42:01,200
is it's still moving in real speed

1067
00:42:05,450 --> 00:42:03,930
faster than the one in front of it we

1068
00:42:07,310 --> 00:42:05,460
just sort of we're seeing everything

1069
00:42:09,770 --> 00:42:07,320
it's like putting your video on

1070
00:42:10,299 --> 00:42:09,780
fast-forward that makes sense yeah yeah

1071
00:42:11,769 --> 00:42:10,309
that does

1072
00:42:13,660 --> 00:42:11,779
that's right that's a cool effect and

1073
00:42:15,789 --> 00:42:13,670
unfortunately for us as well the impress

1074
00:42:18,279 --> 00:42:15,799
is also asking on YouTube is there a

1075
00:42:20,559 --> 00:42:18,289
relation between the mass of the black

1076
00:42:23,769 --> 00:42:20,569
hole and the presence of these types of

1077
00:42:26,469 --> 00:42:23,779
jets uh that's funny because there's a

1078
00:42:30,339 --> 00:42:26,479
press release for another paper today by

1079
00:42:31,719 --> 00:42:30,349
Mark okoboji that says yes I think

1080
00:42:34,420 --> 00:42:31,729
that's I think that paper came out

1081
00:42:36,009 --> 00:42:34,430
anyway but he there is a there is a

1082
00:42:37,390 --> 00:42:36,019
let's say an argument that that's the

1083
00:42:39,910 --> 00:42:37,400
case I don't know that it's been a

1084
00:42:41,829 --> 00:42:39,920
hundred percent established but but let

1085
00:42:42,969 --> 00:42:41,839
me also add to that that you know we

1086
00:42:44,709 --> 00:42:42,979
mentioned at the beginning of the

1087
00:42:46,420 --> 00:42:44,719
hangout that there is really these two

1088
00:42:48,579 --> 00:42:46,430

types of black holes that we know exists

1089
00:42:50,769 --> 00:42:48,589
in the universe one we call stellar-mass

1090
00:42:53,620 --> 00:42:50,779
black holes and we know they form from

1091
00:42:55,299 --> 00:42:53,630
the evolution of a normal star so a very

1092
00:42:57,519 --> 00:42:55,309
massive start at the end of its lifetime

1093
00:42:59,349 --> 00:42:57,529
will undergo supernova will become a

1094
00:43:01,420 --> 00:42:59,359
black hole and we also know of these

1095
00:43:03,160 --> 00:43:01,430
black holes that are a million or a

1096
00:43:05,410 --> 00:43:03,170
billion times more massive and sit in

1097
00:43:07,539 --> 00:43:05,420
the Centers of galaxies now we do

1098
00:43:09,189 --> 00:43:07,549
actually know that some stellar mass

1099
00:43:13,779 --> 00:43:09,199
black holes or Stella most compact

1100
00:43:15,789 --> 00:43:13,789
objects do have Jets as well so you know

1101
00:43:18,910 --> 00:43:15,799
while the mass may certainly play a role

1102
00:43:21,130 --> 00:43:18,920
in how things you know appear to us or

1103
00:43:23,229 --> 00:43:21,140
you know how prominent to jet maybe it's

1104
00:43:25,059 --> 00:43:23,239
it's certainly not that you can only get

1105
00:43:26,589 --> 00:43:25,069
a jet if you have a black hole above a

1106
00:43:29,049 --> 00:43:26,599
certain mass because we already know

1107
00:43:30,849 --> 00:43:29,059
that we find them in objects whose mass

1108
00:43:33,249 --> 00:43:30,859
is different by as much as a factor of a

1109
00:43:34,749 --> 00:43:33,259
building so plays a role but it's still

1110
00:43:36,549 --> 00:43:34,759
a much more complex for normal and than

1111
00:43:38,709 --> 00:43:36,559
just a mass it's not just a mass that's

1112
00:43:40,779 --> 00:43:38,719
regulating excellent that's a great

1113
00:43:43,150 --> 00:43:40,789

question thanks to me I appreciate that

1114
00:43:45,400 --> 00:43:43,160
okay so let me I think that's all of our

1115
00:43:49,809 --> 00:43:45,410
questions that we had 0 1 0 I got more

1116
00:43:52,779 --> 00:43:49,819
now let's see let me let me see here dan

1117
00:43:55,059 --> 00:43:52,789
Buddha's asking on the Q&A app all all

1118
00:43:57,069 --> 00:43:55,069
the black holes all the black holes at

1119
00:43:59,410 --> 00:43:57,079
one time emit jets or what condition is

1120
00:44:01,329 --> 00:43:59,420
needed for the black holes to emit jets

1121
00:44:02,919 --> 00:44:01,339
and we alluded to that earlier you need

1122
00:44:05,589 --> 00:44:02,929
to be feeding it right it has to have

1123
00:44:07,209 --> 00:44:05,599
material falling in before these Jets

1124
00:44:09,819 --> 00:44:07,219
will appear so that we talked about that

1125
00:44:11,739 --> 00:44:09,829
earlier on uh what does stephen hawking

1126
00:44:13,779 --> 00:44:11,749
have to say about this charles bell is

1127
00:44:16,569 --> 00:44:13,789
asking i don't know we're not babies on

1128
00:44:19,179 --> 00:44:16,579
in our hangout well we can call them up

1129
00:44:23,220 --> 00:44:19,189
yeah it's calling my i don't know don't

1130
00:44:28,690 --> 00:44:25,540
yeah sorry don't know girl but that's

1131
00:44:29,980 --> 00:44:28,700
you know well maybe we'll try to reach

1132
00:44:33,310 --> 00:44:29,990
him and maybe he'll be on the future

1133
00:44:35,440 --> 00:44:33,320
hang out okay so um duh I have a

1134
00:44:38,640 --> 00:44:35,450
question I ok and I know that you've

1135
00:44:44,140 --> 00:44:38,650
looked at one other example of this um

1136
00:44:46,180 --> 00:44:44,150
but there are many known examples of

1137
00:44:48,760 --> 00:44:46,190
this phenomenon and we just don't know

1138
00:44:51,430 --> 00:44:48,770

the details of the Jets and what they're

1139
00:44:54,630 --> 00:44:51,440
doing so it's possible that many of the

1140
00:44:59,410 --> 00:44:54,640
Jets and ellipticals are we doing this

1141
00:45:02,080 --> 00:44:59,420
yes yeah um so we are only just now able

1142
00:45:03,880 --> 00:45:02,090
partly because of the you know the

1143
00:45:05,260 --> 00:45:03,890
developments of this trauma tree is

1144
00:45:08,650 --> 00:45:05,270
basically the field that allows us to

1145
00:45:11,200 --> 00:45:08,660
align these images very very well so

1146
00:45:13,720 --> 00:45:11,210
we've only kind of got that a set of

1147
00:45:15,880 --> 00:45:13,730
tools on hand plus the long lifetimes of

1148
00:45:19,060 --> 00:45:15,890
Hubble to really start looking at the

1149
00:45:22,120 --> 00:45:19,070
local universe Jets as I call them now

1150
00:45:24,400 --> 00:45:22,130
so there's definitely more cases where

1151
00:45:26,020 --> 00:45:24,410
we want to look and we think well we may

1152
00:45:27,970 --> 00:45:26,030
see something similar or we may not

1153
00:45:29,770 --> 00:45:27,980
that's you know it's it's pure

1154
00:45:31,510 --> 00:45:29,780
phenomenology at this point so we're

1155
00:45:33,130 --> 00:45:31,520
going to look and see if all the Jets do

1156
00:45:38,650 --> 00:45:33,140
something similar to this or if this is

1157
00:45:40,300 --> 00:45:38,660
a really strange outlier so it's it's a

1158
00:45:43,390 --> 00:45:40,310
probably expected that we will find more

1159
00:45:46,360 --> 00:45:43,400
of these another question I had is do

1160
00:45:48,100 --> 00:45:46,370
you have any I mean this is lots of

1161
00:45:51,070 --> 00:45:48,110
observing time or whatever but are there

1162
00:45:54,100 --> 00:45:51,080
are correlations of the brightening in

1163
00:45:57,220 --> 00:45:54,110

other wavelengths that you've seen are

1164
00:45:59,950 --> 00:45:57,230
you seeing some kind of a phenomenon

1165
00:46:02,320 --> 00:45:59,960
that produces x-rays that suggests this

1166
00:46:07,020 --> 00:46:02,330
associated with this matter creating the

1167
00:46:09,280 --> 00:46:07,030
blog or it's different that's them

1168
00:46:11,460 --> 00:46:09,290
that's a good question in fact maybe

1169
00:46:14,080 --> 00:46:11,470
Marcos could say something about the

1170
00:46:16,180 --> 00:46:14,090
sort of internal shock theory that we

1171
00:46:20,410 --> 00:46:16,190
think that this why we think is a big

1172
00:46:22,570 --> 00:46:20,420
results for for wider reasons well the

1173
00:46:25,990 --> 00:46:22,580
first thing one is to say is that you do

1174
00:46:28,930 --> 00:46:26,000
expect this flaring up to be manifested

1175
00:46:32,740 --> 00:46:28,940
in the optical the x-rays with a user

1176
00:46:35,440 --> 00:46:32,750
name yeah you exist yeah so that that's

1177
00:46:36,140 --> 00:46:35,450
one thing the other thing the reason

1178
00:46:37,789 --> 00:46:36,150
that this is very

1179
00:46:41,089 --> 00:46:37,799
interesting is that this collision of

1180
00:46:45,289 --> 00:46:41,099
blogs of components has been theorized

1181
00:46:47,809 --> 00:46:45,299
about 30 years ago and has been used a

1182
00:46:50,240 --> 00:46:47,819
lot in another family of service called

1183
00:46:53,000 --> 00:46:50,250
gamma ray bursts these are these are

1184
00:46:56,690 --> 00:46:53,010
stellar phenomena that in the collapse

1185
00:46:59,450 --> 00:46:56,700
of a stellar system they form a jet that

1186
00:47:03,049 --> 00:46:59,460
lasts for a few seconds and we we

1187
00:47:07,069 --> 00:47:03,059
theorize that the missionary get out of

1188
00:47:10,279 --> 00:47:07,079

this comes from lees colliding colliding

1189
00:47:12,740 --> 00:47:10,289
components but this has never been seen

1190
00:47:14,839 --> 00:47:12,750
never and this is the first time we

1191
00:47:17,870 --> 00:47:14,849
actually see we see two components

1192
00:47:20,599 --> 00:47:17,880
actually colliding that is that is

1193
00:47:24,859 --> 00:47:20,609
honestly the reason this results found

1194
00:47:27,859 --> 00:47:24,869
its way to nature yeah I see I see but

1195
00:47:31,370 --> 00:47:27,869
this is it a massively larger scale

1196
00:47:35,329 --> 00:47:31,380
that's right and the gamma great or

1197
00:47:37,309 --> 00:47:35,339
sources yeah wow that's amazing as you

1198
00:47:40,069 --> 00:47:37,319
say the phenomenon sort of occurs at

1199
00:47:42,140 --> 00:47:40,079
many different scales not just to the

1200
00:47:44,150 --> 00:47:42,150
scale of supermassive black holes but

1201
00:47:46,609 --> 00:47:44,160
all the way down to sell enough that's

1202
00:47:48,650 --> 00:47:46,619
right okay let me just get a little

1203
00:47:50,150 --> 00:47:48,660
clarification from fubar Gord she says

1204
00:47:52,339 --> 00:47:50,160
part of the river for the record my nick

1205
00:47:56,150 --> 00:47:52,349
is the first default variable name fubar

1206
00:47:58,910 --> 00:47:56,160
yeah I knew that followed by the second

1207
00:48:00,650 --> 00:47:58,920
followed by who knows what okay so yes I

1208
00:48:02,089 --> 00:48:00,660
can't you don't look very chic that it's

1209
00:48:04,099 --> 00:48:02,099
also a really good question you asked so

1210
00:48:05,809 --> 00:48:04,109
you know that overcomes any any

1211
00:48:08,089 --> 00:48:05,819
strangeness and your handle for sure

1212
00:48:09,559 --> 00:48:08,099
okay I think I think that's it for this

1213
00:48:11,870 --> 00:48:09,569

week's car do you have any daddy any

1214
00:48:14,870 --> 00:48:11,880
quick any quick the only thing I'm

1215
00:48:16,460 --> 00:48:14,880
saying there is Michael jovens uh what

1216
00:48:17,630 --> 00:48:16,470
about your just think about the the BBQ

1217
00:48:25,390 --> 00:48:17,640
could have like no we have spaghetti

1218
00:48:31,010 --> 00:48:28,880
head coach all right good well I want to

1219
00:48:32,510 --> 00:48:31,020
thank you eileen and rollin and then

1220
00:48:33,859 --> 00:48:32,520
marcos thank you for joining us this is

1221
00:48:35,660 --> 00:48:33,869
excellent work we look forward to

1222
00:48:37,279 --> 00:48:35,670
hearing more from you and Aileen as you

1223
00:48:38,329 --> 00:48:37,289
get more information from these Jets you

1224
00:48:40,400 --> 00:48:38,339
come back and let us know about them

1225
00:48:42,980 --> 00:48:40,410
absolutely all right thank you guys for

1226
00:48:47,720 --> 00:48:42,990
being in our hangout that's it our

1227
00:48:57,120 --> 00:48:51,420
yeah that's right that's right accretion

1228
00:48:58,410 --> 00:48:57,130
disk every campus okay all right so

1229
00:48:59,550 --> 00:48:58,420
that's it for this week though thank you

1230
00:49:05,250 --> 00:48:59,560
all for watching next week we're going

1231
00:49:07,290 --> 00:49:05,260
to be talking about Pluto yeah this non

1232
00:49:09,300 --> 00:49:07,300
planet are doing very strange bizarre

1233
00:49:11,550 --> 00:49:09,310
things Hubble watched it looked at it

1234
00:49:13,319 --> 00:49:11,560
measured it and we are going to show you

1235
00:49:15,540 --> 00:49:13,329
what these moons are doing next week so

1236
00:49:18,359 --> 00:49:15,550
we look forward to seeing you again and

1237
00:49:20,130 --> 00:49:18,369
as on behalf of Carol and Scott guys

1238
00:49:23,160 --> 00:49:20,140

this was another great hangout thank you

1239
00:49:25,680 --> 00:49:23,170
very much and as always thank you keep

1240
00:49:28,140 --> 00:49:25,690
watching and keep us I messed it up as