PUBLIC LECTURE SERIES

Active Galaxies:
Monsters of the Deep (Space)

Featuring Guest Speaker:
Travis Fischer

1
00:00:00,000 --> 00:00:04,850
oh

2
00:00:10,549 --> 00:00:07,550
welcome to the Space Telescope public

3
00:00:13,490 --> 00:00:10,559
lecture series tonight's talk

4
00:00:15,289 --> 00:00:13,500
active galaxies Monsters of the deep

5
00:00:17,210 --> 00:00:15,299
space

6
00:00:20,390 --> 00:00:17,220
Travis Fisher from the Space Telescope

7
00:00:22,730 --> 00:00:20,400
Science Institute will be presenting I

8
00:00:24,950 --> 00:00:22,740
am your host Dr Frank Summers of the

9
00:00:28,370 --> 00:00:24,960
Office of Public Outreach here at the

10
00:00:30,410 --> 00:00:28,380
Space Telescope Science Institute I note

11
00:00:33,490 --> 00:00:30,420
that our public lecture series will

12
00:00:37,069 --> 00:00:33,500
continue to be online only throughout

13
00:00:39,470 --> 00:00:37,079

2023 and of course I always want to

14
00:00:41,810 --> 00:00:39,480
thank our amazing Tech team which is

15
00:00:43,729 --> 00:00:41,820
usually Thomas marufu and Grant Justice

16
00:00:46,790 --> 00:00:43,739
however playing the part of Thomas

17
00:00:49,369 --> 00:00:46,800
merufu tonight is Kevin Flynn thank you

18
00:00:50,990 --> 00:00:49,379
Kevin for filling in kind of last minute

19
00:00:54,290 --> 00:00:51,000
because it was only this afternoon that

20
00:00:59,090 --> 00:00:54,300
we had to change change up our personnel

21
00:01:02,510 --> 00:00:59,100
our upcoming talks uh in April uh

22
00:01:05,570 --> 00:01:02,520
exploring Rocky worlds on the precipice

23
00:01:07,490 --> 00:01:05,580
of a new frontier by Catherine Bennett

24
00:01:11,330 --> 00:01:07,500
also of space-based telescope Science

25
00:01:12,950 --> 00:01:11,340
Institute in May Amanda pagul will be

26
00:01:15,530 --> 00:01:12,960
presenting a talk that doesn't have an

27
00:01:18,410 --> 00:01:15,540
exact title yet but it will be on Galaxy

28
00:01:20,749 --> 00:01:18,420
clusters and the frontier Fields so

29
00:01:22,030 --> 00:01:20,759
these are galaxies out at the edge of

30
00:01:25,789 --> 00:01:22,040
the universe

31
00:01:28,789 --> 00:01:25,799
and on June our June talk will be done

32
00:01:31,850 --> 00:01:28,799
in a association with a science

33
00:01:34,910 --> 00:01:31,860
conference on the Nancy Grace Roman

34
00:01:37,670 --> 00:01:34,920
Space Telescope so they have asked us if

35
00:01:40,130 --> 00:01:37,680
we can delay it and actually put it on a

36
00:01:44,390 --> 00:01:40,140
Thursday yes not a Tuesday night a

37
00:01:47,030 --> 00:01:44,400
Thursday uh June 22nd so note that

38
00:01:51,230 --> 00:01:49,010

about the Nancy Grace Roman Space

39
00:01:53,690 --> 00:01:51,240
Telescope uh but they haven't told me

40
00:01:56,929 --> 00:01:53,700
who their speaker is going to be so uh

41
00:01:59,030 --> 00:01:56,939
that will be a special event uh and I I

42
00:02:02,210 --> 00:01:59,040
will give you the details of that next

43
00:02:04,870 --> 00:02:02,220
month or you can find them on our

44
00:02:10,910 --> 00:02:08,570
www.stsci.edu public hyphen lectures

45
00:02:13,670 --> 00:02:10,920
where you will find this webpage

46
00:02:16,790 --> 00:02:13,680
in the left you can see the link to our

47
00:02:20,570 --> 00:02:16,800
webcast both our YouTube playlist and

48
00:02:23,570 --> 00:02:20,580
our webcasting on the stsci webcasting

49
00:02:26,990 --> 00:02:23,580
page and on the right you can see how

50
00:02:29,330 --> 00:02:27,000
easy it is to sign up for our uh monthly

51
00:02:31,910 --> 00:02:29,340
emails uh just enter your email address

52
00:02:35,690 --> 00:02:31,920
hit that subscribe button and you'll get

53
00:02:38,390 --> 00:02:35,700
like two maybe three emails per month

54
00:02:41,089 --> 00:02:38,400
also on our website are our list of

55
00:02:43,070 --> 00:02:41,099
upcoming lectures and if you click on

56
00:02:45,650 --> 00:02:43,080
any one of those lectures you will get

57
00:02:48,530 --> 00:02:45,660
the full details including its

58
00:02:51,170 --> 00:02:48,540
description and links to the sdsci

59
00:02:53,750 --> 00:02:51,180
webcast after it's been recorded and

60
00:02:57,290 --> 00:02:53,760
also links to YouTube

61
00:02:59,809 --> 00:02:57,300
uh our email we send it out uh just as I

62
00:03:02,030 --> 00:02:59,819
said a couple times a month I showed you

63
00:03:04,670 --> 00:03:02,040

how to sign up the website you can also

64
00:03:08,270 --> 00:03:04,680
to get notifications subscribe to our

65
00:03:10,130 --> 00:03:08,280
YouTube channel youtube.com Hubble Space

66
00:03:13,009 --> 00:03:10,140
Telescope all one word Hubble Space

67
00:03:15,830 --> 00:03:13,019
Telescope uh you'll get the notices of

68
00:03:17,630 --> 00:03:15,840
new videos as well as reminders of Live

69
00:03:19,309 --> 00:03:17,640
Events like this

70
00:03:21,050 --> 00:03:19,319
finally if you have comments or

71
00:03:25,970 --> 00:03:21,060
questions you can send them to public

72
00:03:31,009 --> 00:03:28,970
we handle social media here for the

73
00:03:33,170 --> 00:03:31,019
Hubble Space Telescope for the web Space

74
00:03:35,509 --> 00:03:33,180
Telescope and for the Space Telescope

75
00:03:38,630 --> 00:03:35,519
Science Institute and you'll find them

76
00:03:42,890 --> 00:03:38,640
on Facebook Twitter Youtube and

77
00:03:46,070 --> 00:03:42,900
Instagram Instagram at the uh addresses

78
00:03:47,690 --> 00:03:46,080
listed I don't do much social media so

79
00:03:49,250 --> 00:03:47,700
if you want to follow me you're going to

80
00:03:51,470 --> 00:03:49,260
be kind of bored

81
00:03:53,449 --> 00:03:51,480
um but you will find a few interesting

82
00:03:56,449 --> 00:03:53,459
things every now and then on Facebook

83
00:03:59,330 --> 00:03:56,459
and Twitter at Dr Frank Summers

84
00:04:02,089 --> 00:03:59,340
and now our news from the universe for

85
00:04:05,570 --> 00:04:02,099
March 2023

86
00:04:10,190 --> 00:04:05,580
our first story for you the bespoke

87
00:04:12,770 --> 00:04:10,200
rings of Saturn well Hubble has taken a

88
00:04:15,949 --> 00:04:12,780

lot of images of Saturn

89
00:04:19,129 --> 00:04:15,959
um and in the late 1990s we that we got

90
00:04:20,930 --> 00:04:19,139
images of Saturn every single year and

91
00:04:27,650 --> 00:04:20,940
you can see in the upper left starting

92
00:04:31,430 --> 00:04:27,660
in December 1994 and then 95 96 97 98 99

93
00:04:34,610 --> 00:04:31,440
and 2000 and you can see how the

94
00:04:38,030 --> 00:04:34,620
orientation of Saturn relative to Earth

95
00:04:40,909 --> 00:04:38,040
changes as Saturn moves around its orbit

96
00:04:43,070 --> 00:04:40,919
because it's not flat that ring plane

97
00:04:46,370 --> 00:04:43,080
isn't flat to the ecliptic it's actually

98
00:04:48,050 --> 00:04:46,380
tilted so as Saturn moves around the

99
00:04:50,210 --> 00:04:48,060
solar system

100
00:04:53,150 --> 00:04:50,220
um the ring plane looked at different

101
00:04:56,570 --> 00:04:53,160
various tilts and Saturn actually takes

102
00:04:59,950 --> 00:04:56,580
about 30 years to complete an orbit so

103
00:05:03,650 --> 00:04:59,960
each season on Saturn lasts for about

104
00:05:06,590 --> 00:05:03,660
seven years that'll be important in just

105
00:05:09,469 --> 00:05:06,600
a second we continue to take pictures of

106
00:05:13,450 --> 00:05:09,479
images matter of fact we have the outer

107
00:05:17,030 --> 00:05:13,460
planets uh Legacy program called opal

108
00:05:21,469 --> 00:05:17,040
and opal got this beautiful image of

109
00:05:23,390 --> 00:05:21,479
Saturn in September of 2022. yeah just

110
00:05:26,270 --> 00:05:23,400
another gorgeous image Saturn's just

111
00:05:28,550 --> 00:05:26,280
beautiful okay you know we can't these

112
00:05:30,830 --> 00:05:28,560
we're always really interested uh on

113
00:05:32,510 --> 00:05:30,840

seeing Saturn how Saturn looks and with

114
00:05:34,189 --> 00:05:32,520
the opal program in particular they're

115
00:05:37,930 --> 00:05:34,199
studying the atmosphere and how it

116
00:05:40,730 --> 00:05:37,940
changes however this image is special

117
00:05:43,430 --> 00:05:40,740
not because of the atmosphere which is

118
00:05:47,029 --> 00:05:43,440
still cool okay it's still cool but it's

119
00:05:49,070 --> 00:05:47,039
also because in this image ring spokes

120
00:05:51,529 --> 00:05:49,080
appeared you see that those little

121
00:05:56,390 --> 00:05:51,539
blotches there in the in in the Rings

122
00:05:59,870 --> 00:05:56,400
those are called ring spokes okay and

123
00:06:02,629 --> 00:05:59,880
this is a new thing recently okay we

124
00:06:06,529 --> 00:06:02,639
have seen them originally started with

125
00:06:10,730 --> 00:06:06,539
the Voyager 2 and Voyager 2 went by um

126
00:06:13,370 --> 00:06:10,740
Saturn in August of 1981 and again you

127
00:06:15,050 --> 00:06:13,380
can see these smudges in the Rings uh

128
00:06:17,090 --> 00:06:15,060
which is the first time we ever saw

129
00:06:19,850 --> 00:06:17,100
these ring spokes

130
00:06:21,050 --> 00:06:19,860
they were also seen by the Cassini

131
00:06:23,990 --> 00:06:21,060
Mission remember the Cassini mission

132
00:06:26,990 --> 00:06:24,000
that was at Saturn for like a decade uh

133
00:06:29,689 --> 00:06:27,000
the Cassini Mission saw them starting in

134
00:06:31,850 --> 00:06:29,699
September 2005. and here you can see

135
00:06:34,490 --> 00:06:31,860
instead of being the dark smudges that

136
00:06:36,290 --> 00:06:34,500
Hubble and voyagers uh saw in those

137
00:06:38,029 --> 00:06:36,300
previous two images here you have some

138
00:06:40,550 --> 00:06:38,039

bright ring spokes

139
00:06:42,350 --> 00:06:40,560
um in uh Saturn's rings in September

140
00:06:45,890 --> 00:06:42,360
2005.

141
00:06:48,770 --> 00:06:45,900
so why is the seasons on Saturn

142
00:06:51,650 --> 00:06:48,780
important because astronomers seem to

143
00:06:54,650 --> 00:06:51,660
have noticed that the ring spokes might

144
00:06:58,490 --> 00:06:54,660
have something to do with when Saturn is

145
00:07:00,890 --> 00:06:58,500
at equinox okay so uh Equinox is the

146
00:07:03,290 --> 00:07:00,900
separate is the transfer from Winter to

147
00:07:05,510 --> 00:07:03,300
Spring they have a spring equinox and

148
00:07:08,270 --> 00:07:05,520
then it's also the transfers from Summer

149
00:07:09,290 --> 00:07:08,280
uh to fall which is the fall equinox

150
00:07:13,370 --> 00:07:09,300
right

151
00:07:16,370 --> 00:07:13,380
so at the equinoxes

152
00:07:19,189 --> 00:07:16,380
um they find that this spoke activity is

153
00:07:22,730 --> 00:07:19,199
more prevalent or is only prevalent

154
00:07:25,909 --> 00:07:22,740
around the equinoxes and so if you

155
00:07:29,029 --> 00:07:25,919
notice here in August 1995 you can see

156
00:07:32,270 --> 00:07:29,039
the Rings Edge on that would be

157
00:07:35,150 --> 00:07:32,280
um uh around the Equinox when Saturn's

158
00:07:38,170 --> 00:07:35,160
rings are flat on to to the sun okay

159
00:07:41,570 --> 00:07:38,180
that would be the transfer between

160
00:07:44,629 --> 00:07:41,580
Northern uh winter and

161
00:07:47,150 --> 00:07:44,639
um uh and spring or between summer and

162
00:07:50,450 --> 00:07:47,160
fall I'm not exactly sure I guess this

163
00:07:53,210 --> 00:07:50,460

one is going into Southern uh summer uh

164
00:07:56,330 --> 00:07:53,220
going in the sequence that we see here

165
00:07:59,029 --> 00:07:56,340
well what we know about Saturn now is

166
00:08:03,890 --> 00:07:59,039
the next Equinox is coming up in two

167
00:08:06,409 --> 00:08:03,900
years in May 2025 and so the astronomers

168
00:08:09,469 --> 00:08:06,419
are excited to see these spokes with

169
00:08:12,290 --> 00:08:09,479
Hubble uh and and have the clarity to be

170
00:08:14,270 --> 00:08:12,300
able to look at them and to study them

171
00:08:17,390 --> 00:08:14,280
over the course as we progress into the

172
00:08:19,550 --> 00:08:17,400
equinox and after the Equinox to see how

173
00:08:22,189 --> 00:08:19,560
these spokes are because

174
00:08:26,330 --> 00:08:22,199
we don't actually know why the spokes

175
00:08:28,610 --> 00:08:26,340
appear uh there is a dominant idea a

176
00:08:32,149 --> 00:08:28,620
hypothesis that has something to do with

177
00:08:34,670 --> 00:08:32,159
Saturn's magnetic fields and so that uh

178
00:08:37,490 --> 00:08:34,680
that I'm not exactly sure why that would

179
00:08:38,990 --> 00:08:37,500
be activated at equinox but that's what

180
00:08:41,389 --> 00:08:39,000
they tell me that it has something to do

181
00:08:44,149 --> 00:08:41,399
with the the orientation of Saturn's

182
00:08:46,010 --> 00:08:44,159
magnetic field as we get to Equinox and

183
00:08:48,889 --> 00:08:46,020
so they're going to be looking at Saturn

184
00:08:52,009 --> 00:08:48,899
carefully over the next several years to

185
00:08:53,750 --> 00:08:52,019
see if they can test this hypothesis and

186
00:08:56,150 --> 00:08:53,760
what they can come up with as to what

187
00:08:59,030 --> 00:08:56,160
are the reasons that these spokes appear

188
00:09:01,490 --> 00:08:59,040

and that they seem to be seasonal in

189
00:09:05,150 --> 00:09:01,500
their appearance

190
00:09:08,630 --> 00:09:05,160
our Second Story is detailed Galactic

191
00:09:11,449 --> 00:09:08,640
structure with fangs yes gonna sink our

192
00:09:14,750 --> 00:09:11,459
teeth into this story here let's start

193
00:09:16,670 --> 00:09:14,760
with a ground-based image okay this is a

194
00:09:20,150 --> 00:09:16,680
ground-based image of the whirlpool

195
00:09:22,850 --> 00:09:20,160
Galaxy also known as messy A51

196
00:09:25,910 --> 00:09:22,860
honestly it's my favorite Galaxy okay

197
00:09:28,850 --> 00:09:25,920
it's just a gorgeous Grand Design spiral

198
00:09:30,829 --> 00:09:28,860
galaxy but what's really cool is when

199
00:09:33,230 --> 00:09:30,839
you look at the

200
00:09:37,490 --> 00:09:33,240
view invisible light

201
00:09:39,230 --> 00:09:37,500
and you contrast it to the view in

202
00:09:42,710 --> 00:09:39,240
infrared from the Spitzer Space

203
00:09:44,329 --> 00:09:42,720
Telescope all right so this is the

204
00:09:47,269 --> 00:09:44,339
visible light View

205
00:09:49,970 --> 00:09:47,279
and this is the infrared View

206
00:09:52,730 --> 00:09:49,980
and it's really kind of cool because you

207
00:09:54,769 --> 00:09:52,740
see all this glowing gas in infrared

208
00:09:57,650 --> 00:09:54,779
well if you go back to the invisible

209
00:10:01,190 --> 00:09:57,660
light that's all the dark gas those dark

210
00:10:05,810 --> 00:10:01,200
dust lanes that are opaque invisible

211
00:10:08,269 --> 00:10:05,820
light become emissive in infrared light

212
00:10:10,730 --> 00:10:08,279
and you get to see all that internal

213
00:10:12,110 --> 00:10:10,740

structure of the gas within the spiral

214
00:10:14,990 --> 00:10:12,120
galaxy

215
00:10:17,509 --> 00:10:15,000
the thing is however Spitzer isn't that

216
00:10:20,030 --> 00:10:17,519
high resolution especially if I take

217
00:10:22,610 --> 00:10:20,040
that Spitzer image and then I compare it

218
00:10:24,410 --> 00:10:22,620
to the hobble image and it's like whoa

219
00:10:27,650 --> 00:10:24,420
whoa there's just so much more

220
00:10:30,290 --> 00:10:27,660
resolution in the Hubble image okay oh I

221
00:10:31,730 --> 00:10:30,300
left kpno here that's not kid Peak

222
00:10:34,430 --> 00:10:31,740
National observator this is a whole

223
00:10:36,710 --> 00:10:34,440
image okay oops my bad

224
00:10:38,329 --> 00:10:36,720
um but here's the Spitzer image and

225
00:10:41,570 --> 00:10:38,339
there's the Hubble image and the Hubble

226
00:10:43,790 --> 00:10:41,580
Is Such higher resolution wouldn't it be

227
00:10:46,190 --> 00:10:43,800
really cool if we had an infrared

228
00:10:48,410 --> 00:10:46,200
telescope with the same resolution as

229
00:10:51,290 --> 00:10:48,420
Hubble to see the same those structures

230
00:10:52,490 --> 00:10:51,300
in this kind of detail and of course you

231
00:10:54,350 --> 00:10:52,500
know where I'm going with this because

232
00:10:57,170 --> 00:10:54,360
we have the James Webb Space Telescope

233
00:10:59,389 --> 00:10:57,180
up there now but first I need to tell

234
00:11:03,050 --> 00:10:59,399
you a little bit about the fangs survey

235
00:11:06,410 --> 00:11:03,060
okay so the Fang survey started out at

236
00:11:08,990 --> 00:11:06,420
the Atacama large millimeter array Alma

237
00:11:12,110 --> 00:11:09,000
Alma all right it started out as a

238
00:11:15,350 --> 00:11:12,120

survey at Alma to look at nearby spiral

239
00:11:17,389 --> 00:11:15,360
galaxies that says physics at high

240
00:11:20,110 --> 00:11:17,399
angular resolution in nearby galaxies

241
00:11:23,569 --> 00:11:20,120
okay so the NG is nearby yeah

242
00:11:27,530 --> 00:11:23,579
NGS is actually nearby galaxies

243
00:11:31,030 --> 00:11:27,540
gotta get that s in there and Alma is

244
00:11:34,190 --> 00:11:31,040
good as a radio survey of looking at the

245
00:11:37,910 --> 00:11:34,200
carbon monoxide molecule which traces

246
00:11:40,970 --> 00:11:37,920
the cold star-forming gas okay and they

247
00:11:43,250 --> 00:11:40,980
looked at the gas disks in 90 nearby

248
00:11:45,110 --> 00:11:43,260
spiral galaxies to really start to

249
00:11:47,750 --> 00:11:45,120
underlook it then they said let's

250
00:11:50,990 --> 00:11:47,760
contrast that with observations from

251
00:11:55,250 --> 00:11:51,000
other telescopes so they did the fangs

252
00:11:57,350 --> 00:11:55,260
Muse program all right and news is a

253
00:12:01,370 --> 00:11:57,360
instrument on the very large telescope

254
00:12:04,790 --> 00:12:01,380
at Sierra tololo in Chile and it's the

255
00:12:06,590 --> 00:12:04,800
multi-unit spectroscopic Explorer it's

256
00:12:08,750 --> 00:12:06,600
what we call an integral field unit

257
00:12:12,050 --> 00:12:08,760
right and an integral field unit is

258
00:12:15,050 --> 00:12:12,060
really cool because it gets images but

259
00:12:16,610 --> 00:12:15,060
it also gets Spectra at every pixel all

260
00:12:18,889 --> 00:12:16,620
right this is a really cool thing we

261
00:12:21,949 --> 00:12:18,899
actually have an integral field unit on

262
00:12:23,690 --> 00:12:21,959
J2 St it won't be used for this what I'm

263
00:12:28,009 --> 00:12:23,700

talking about now but it's being used

264
00:12:31,550 --> 00:12:28,019
for other things but the muse ifs on the

265
00:12:34,190 --> 00:12:31,560
VLT was able to do observations of many

266
00:12:36,769 --> 00:12:34,200
of these galaxies too I think it says uh

267
00:12:39,889 --> 00:12:36,779
here 19 star forming spiral galaxies

268
00:12:41,569 --> 00:12:39,899
with Muse uh to contrast and then they

269
00:12:44,329 --> 00:12:41,579
said we want the really high resolution

270
00:12:49,250 --> 00:12:44,339
stuff so where are you gonna go you're

271
00:12:52,069 --> 00:12:49,260
gonna do fangs HST all right and so uh

272
00:12:55,190 --> 00:12:52,079
Hubble was able to look at 38 of these

273
00:12:57,230 --> 00:12:55,200
galaxies in Optical light okay and then

274
00:12:59,090 --> 00:12:57,240
if you combine all three of those you

275
00:13:01,069 --> 00:12:59,100
take the alma and the Muse and the

276
00:13:04,610 --> 00:13:01,079
Hubble and put them together in an image

277
00:13:06,650 --> 00:13:04,620
here's what NGC 3351 looks like and so

278
00:13:08,870 --> 00:13:06,660
you've got three different wavelengths

279
00:13:10,670 --> 00:13:08,880
to look at and get all the various

280
00:13:12,430 --> 00:13:10,680
physics of star formation that's going

281
00:13:15,829 --> 00:13:12,440
on in these galaxies

282
00:13:20,530 --> 00:13:15,839
but and you know I was leading here uh

283
00:13:24,050 --> 00:13:20,540
what we really want uh is the fangs j2st

284
00:13:27,050 --> 00:13:24,060
and last month the in the appj letters

285
00:13:29,690 --> 00:13:27,060
uh the first results from the fangs j2st

286
00:13:31,790 --> 00:13:29,700
survey came out okay and they have a

287
00:13:33,650 --> 00:13:31,800
bunch of these galaxies

288
00:13:36,769 --> 00:13:33,660

um they're actually doing 19 different

289
00:13:38,870 --> 00:13:36,779
galaxies with web and so here I am

290
00:13:41,389 --> 00:13:38,880
tonight to show you just the very first

291
00:13:42,769 --> 00:13:41,399
results just that's sort of a teaser of

292
00:13:46,449 --> 00:13:42,779
what's going on

293
00:13:52,430 --> 00:13:46,459
um and we released two images uh NGC

294
00:13:54,530 --> 00:13:52,440
1433 and NGC 7496 and look at this this

295
00:13:56,990 --> 00:13:54,540
is what I was telling you about we're

296
00:13:59,569 --> 00:13:57,000
able to see that detailed structure of

297
00:14:02,210 --> 00:13:59,579
the gas and dust using these mid

298
00:14:05,030 --> 00:14:02,220
infrared observations from the web Space

299
00:14:07,550 --> 00:14:05,040
Telescope and really see the detail in

300
00:14:09,710 --> 00:14:07,560
that fine resolution that I've been

301
00:14:12,050 --> 00:14:09,720
dreaming about for like a decade or two

302
00:14:14,150 --> 00:14:12,060
all right this is really great so we're

303
00:14:17,449 --> 00:14:14,160
able to see the structure going on in

304
00:14:19,250 --> 00:14:17,459
here and so it's really cool in 7496 is

305
00:14:21,110 --> 00:14:19,260
that we're also seeing you see that red

306
00:14:23,690 --> 00:14:21,120
light coming from the center that's an

307
00:14:25,069 --> 00:14:23,700
active Galactic nucleus here all right

308
00:14:27,889 --> 00:14:25,079
and you're going to hear about a few

309
00:14:29,870 --> 00:14:27,899
things about active galaxies here and it

310
00:14:32,269 --> 00:14:29,880
turns out that Jus T's mid infrared

311
00:14:34,850 --> 00:14:32,279
observations actually do see the

312
00:14:38,329 --> 00:14:34,860
emission from the material around active

313
00:14:39,829 --> 00:14:38,339

Galactic nuclei here so this is just the

314
00:14:43,129 --> 00:14:39,839
beginning of what we're going to get

315
00:14:44,930 --> 00:14:43,139
from Fang's web and we're going to have

316
00:14:46,610 --> 00:14:44,940
to do all the correlations across

317
00:14:48,769 --> 00:14:46,620
correlations against the visible light

318
00:14:51,290 --> 00:14:48,779
from Hubble uh the spectroscopic

319
00:14:54,050 --> 00:14:51,300
observations from Muse and the radio

320
00:14:56,629 --> 00:14:54,060
observations from Alma and being able to

321
00:14:59,030 --> 00:14:56,639
look in multiple wavelengths gives us

322
00:15:02,329 --> 00:14:59,040
more information to diagnose the physics

323
00:15:06,189 --> 00:15:02,339
that's going on in the star formation in

324
00:15:14,269 --> 00:15:11,470
so our speaker tonight is Travis Fisher

325
00:15:15,910 --> 00:15:14,279
and he will be talking out to us about

326
00:15:18,230 --> 00:15:15,920
active galaxies

327
00:15:20,689 --> 00:15:18,240
Travis is here at the Space Telescope

328
00:15:24,370 --> 00:15:20,699
Science Institute as an Issa Ora

329
00:15:27,110 --> 00:15:24,380
astronomer and he's been here since 2020

330
00:15:29,509 --> 00:15:27,120
although he tells me he has not spent

331
00:15:33,050 --> 00:15:29,519
much time in his office because he got

332
00:15:36,290 --> 00:15:33,060
here just before the pandemic started

333
00:15:38,930 --> 00:15:36,300
um he uh got his undergraduate degree at

334
00:15:43,730 --> 00:15:38,940
the University of Wisconsin

335
00:15:46,430 --> 00:15:43,740
the the main campus I forget the name of

336
00:15:49,430 --> 00:15:46,440
the the sub campus uh that that he was

337
00:15:50,710 --> 00:15:49,440
at and then he did his graduate work at

338
00:15:53,870 --> 00:15:50,720

Georgia State

339
00:15:57,290 --> 00:15:53,880
and then he was able to move to the

340
00:15:59,569 --> 00:15:57,300
Washington DC Baltimore area and work at

341
00:16:02,350 --> 00:15:59,579
three places the U.S Naval Observatory

342
00:16:05,269 --> 00:16:02,360
uh where it was a research uh researcher

343
00:16:06,530 --> 00:16:05,279
at The Goddard space flight center where

344
00:16:07,389 --> 00:16:06,540
he was a

345
00:16:10,970 --> 00:16:07,399
UST

346
00:16:12,829 --> 00:16:10,980
postdoctoral fellow and then finally he

347
00:16:15,110 --> 00:16:12,839
settled here at the Space Telescope

348
00:16:17,689 --> 00:16:15,120
Science Institute

349
00:16:19,670 --> 00:16:17,699
um so it's been nice that his many

350
00:16:22,250 --> 00:16:19,680
astronomers actually move all around the

351
00:16:24,889 --> 00:16:22,260
globe during that period after graduate

352
00:16:26,090 --> 00:16:24,899
school but he's been able to have a

353
00:16:27,889 --> 00:16:26,100
relatively

354
00:16:31,430 --> 00:16:27,899
um uh

355
00:16:33,230 --> 00:16:31,440
relatively calm moving possibility which

356
00:16:36,290 --> 00:16:33,240
has allowed him to develop his family

357
00:16:39,590 --> 00:16:36,300
he's got two kids uh he says he likes

358
00:16:41,509 --> 00:16:39,600
hiking and the outdoors so hopefully we

359
00:16:44,749 --> 00:16:41,519
won't lose him to Colorado like where

360
00:16:46,610 --> 00:16:44,759
several of our friends uh many of some

361
00:16:48,170 --> 00:16:46,620
of my my friends who are astronomers

362
00:16:50,749 --> 00:16:48,180
love it because they get they really

363
00:16:52,970 --> 00:16:50,759

enjoy the hiking Outdoors but we got

364
00:16:56,749 --> 00:16:52,980
Travis here and we're keeping him so

365
00:16:58,790 --> 00:16:56,759
ladies and gentlemen uh Dr Travis Fisher

366
00:17:00,889 --> 00:16:58,800
Frank thank you so much thank you very

367
00:17:04,669 --> 00:17:00,899
much for having me tonight

368
00:17:06,949 --> 00:17:04,679
uh so yeah let's get to it

369
00:17:09,710 --> 00:17:06,959
so yeah I'm here tonight to talk to

370
00:17:11,510 --> 00:17:09,720
everybody about active galaxies and this

371
00:17:13,970 --> 00:17:11,520
is just like a broad

372
00:17:16,250 --> 00:17:13,980
um talk to kind of understand why we

373
00:17:18,650 --> 00:17:16,260
consider them the monsters of the

374
00:17:21,289 --> 00:17:18,660
universe the monsters of the deep space

375
00:17:23,270 --> 00:17:21,299
right uh and so before we get there

376
00:17:25,130 --> 00:17:23,280
we're gonna have to kind of slow it down

377
00:17:28,429 --> 00:17:25,140
and just start with the building blocks

378
00:17:30,710 --> 00:17:28,439
about like what is like a Galaxy first

379
00:17:33,169 --> 00:17:30,720
of all so that I mean we can't just jump

380
00:17:35,750 --> 00:17:33,179
right into AGN so what is a Galaxy by

381
00:17:38,810 --> 00:17:35,760
itself first of all and so

382
00:17:40,549 --> 00:17:38,820
um a Galaxy uh is going to be just a

383
00:17:42,890 --> 00:17:40,559
cluster of stop of billions of stars

384
00:17:44,810 --> 00:17:42,900
billions of stars uh and sell them some

385
00:17:48,110 --> 00:17:44,820
gas and some dust that's all held

386
00:17:49,909 --> 00:17:48,120
together by gravity so these are Hubble

387
00:17:52,310 --> 00:17:49,919
images of a of a bunch of nearby

388
00:17:54,590 --> 00:17:52,320

galaxies as part of this Legos survey

389
00:17:56,390 --> 00:17:54,600
and we can see uh it looks like static

390
00:17:57,950 --> 00:17:56,400
but each one of these individual pixel

391
00:18:00,650 --> 00:17:57,960
these little static points are actually

392
00:18:02,570 --> 00:18:00,660
resolved stars in these systems and we

393
00:18:05,210 --> 00:18:02,580
can see that most of the space here is

394
00:18:06,350 --> 00:18:05,220
actually uh empty but then each one of

395
00:18:08,330 --> 00:18:06,360
these little pixels that we're seeing

396
00:18:10,549 --> 00:18:08,340
little granulations from those are

397
00:18:13,190 --> 00:18:10,559
individual stars that live in these in

398
00:18:15,590 --> 00:18:13,200
these uh little communities so we

399
00:18:17,570 --> 00:18:15,600
ourselves live in a galaxy the solar

400
00:18:19,310 --> 00:18:17,580
system lives in a spiral galaxy called

401
00:18:21,169 --> 00:18:19,320
the Milky Way and it doesn't look like

402
00:18:23,510 --> 00:18:21,179
any other Galaxy that we look at because

403
00:18:25,909 --> 00:18:23,520
we're living in it right so it looks

404
00:18:29,270 --> 00:18:25,919
much more spread out into a simple line

405
00:18:31,010 --> 00:18:29,280
and so here is the image that we usually

406
00:18:32,990 --> 00:18:31,020
take from Earth if you're looking up in

407
00:18:35,450 --> 00:18:33,000
the night sky is what you would see and

408
00:18:37,610 --> 00:18:35,460
then below that is going to be a cartoon

409
00:18:40,250 --> 00:18:37,620
of what we think the Milky Way looks

410
00:18:42,650 --> 00:18:40,260
like today and so you can kind of put

411
00:18:44,330 --> 00:18:42,660
yourself in perspective here if we

412
00:18:46,549 --> 00:18:44,340
um how it looks in the image and how it

413
00:18:48,289 --> 00:18:46,559

looks from the cartoon is we can just do

414
00:18:51,049 --> 00:18:48,299
like a 360

415
00:18:52,909 --> 00:18:51,059
around the cartoon and get an idea that

416
00:18:55,430 --> 00:18:52,919
and the entire line that you're seeing

417
00:18:58,730 --> 00:18:55,440
in this image of the Milky Way is 100 or

418
00:19:01,549 --> 00:18:58,740
360 Degrees around us

419
00:19:04,010 --> 00:19:01,559
um and so galaxies uh at the center of

420
00:19:06,049 --> 00:19:04,020
every Galaxy or at almost every Galaxy

421
00:19:08,990 --> 00:19:06,059
but we're pretty sure they're in almost

422
00:19:11,930 --> 00:19:09,000
all of them is a supermassive black hole

423
00:19:13,190 --> 00:19:11,940
and so here is the image of the black

424
00:19:15,650 --> 00:19:13,200
hole this impressive black hole that

425
00:19:18,350 --> 00:19:15,660
lives in the center of our galaxy we've

426
00:19:21,409 --> 00:19:18,360
named it Sagittarius A star because we

427
00:19:23,450 --> 00:19:21,419
like naming them interesting names and

428
00:19:24,770 --> 00:19:23,460
so this is an image

429
00:19:28,490 --> 00:19:24,780
um taken from the Event Horizon

430
00:19:31,070 --> 00:19:28,500
telescope uh not too long ago and so

431
00:19:32,870 --> 00:19:31,080
this is what we um are going to be

432
00:19:35,330 --> 00:19:32,880
focusing on these super massive black

433
00:19:36,409 --> 00:19:35,340
holes that live at the centers of

434
00:19:39,590 --> 00:19:36,419
galaxies

435
00:19:40,970 --> 00:19:39,600
so a lot of every galaxy has one of

436
00:19:42,289 --> 00:19:40,980
these supermassive black holes and so

437
00:19:45,169 --> 00:19:42,299
your question the question would be like

438
00:19:47,150 --> 00:19:45,179

are what is a black hole itself what are

439
00:19:48,590 --> 00:19:47,160
these objects that we have that are

440
00:19:50,990 --> 00:19:48,600
going to be the the basis of this talk

441
00:19:53,990 --> 00:19:51,000
today and so to confirm

442
00:19:56,630 --> 00:19:54,000
um they are not a wormhole they are not

443
00:19:58,250 --> 00:19:56,640
a portal they're not a Time riff they're

444
00:20:01,010 --> 00:19:58,260
not some sort of

445
00:20:04,010 --> 00:20:01,020
um gateway to another dimension it's uh

446
00:20:07,070 --> 00:20:04,020
often you see this sort of like tear in

447
00:20:09,110 --> 00:20:07,080
the space-time Continuum and have people

448
00:20:12,409 --> 00:20:09,120
able to travel through them in science

449
00:20:14,750 --> 00:20:12,419
fiction or and so what we want to

450
00:20:18,289 --> 00:20:14,760
confirm right now is that these things

451
00:20:20,150 --> 00:20:18,299
these black holes are objects all right

452
00:20:22,310 --> 00:20:20,160
they're just like everything else that

453
00:20:25,070 --> 00:20:22,320
you would expect to see in the universe

454
00:20:28,070 --> 00:20:25,080
they're just like planets or horses or

455
00:20:31,430 --> 00:20:28,080
gallons of milk these are objects in the

456
00:20:34,310 --> 00:20:31,440
universe that exist and uh the only real

457
00:20:36,590 --> 00:20:34,320
difference between a black hole and

458
00:20:39,409 --> 00:20:36,600
everything else that exists in the

459
00:20:41,270 --> 00:20:39,419
universe is that black holes are

460
00:20:42,409 --> 00:20:41,280
extremely compact

461
00:20:45,650 --> 00:20:42,419
okay

462
00:20:47,810 --> 00:20:45,660
so uh let's try to come up with some

463
00:20:50,510 --> 00:20:47,820

sort of quantitative or maybe a

464
00:20:54,470 --> 00:20:50,520
qualitative comparison of how compact

465
00:20:56,570 --> 00:20:54,480
black holes are so here's a a picture of

466
00:20:59,150 --> 00:20:56,580
a very massive star this is an a-type

467
00:21:02,750 --> 00:20:59,160
star much more massive than our sun

468
00:21:04,789 --> 00:21:02,760
about eight times the mass of uh the Sun

469
00:21:07,970 --> 00:21:04,799
that we live around in the solar system

470
00:21:09,830 --> 00:21:07,980
and so when a massive star like this

471
00:21:12,710 --> 00:21:09,840
ends its life cycle it's going to

472
00:21:13,730 --> 00:21:12,720
explode and it's going to form a black

473
00:21:17,690 --> 00:21:13,740
hole

474
00:21:19,789 --> 00:21:17,700
this explosion is not going to be the

475
00:21:22,430 --> 00:21:19,799
size of that uh that star it's going to

476
00:21:24,950 --> 00:21:22,440
be much much smaller in fact if we try

477
00:21:27,710 --> 00:21:24,960
to measure what the Event Horizon is or

478
00:21:29,930 --> 00:21:27,720
the the edge of the black hole that we

479
00:21:33,409 --> 00:21:29,940
Define it's going to be about 30 miles

480
00:21:36,350 --> 00:21:33,419
in diameter and so uh for reference

481
00:21:39,529 --> 00:21:36,360
that's maybe the distance to drive

482
00:21:42,190 --> 00:21:39,539
across Rhode Island okay so uh black

483
00:21:45,049 --> 00:21:42,200
holes on the Stellar Mass side are

484
00:21:48,409 --> 00:21:45,059
incredibly small for how much mass is

485
00:21:53,090 --> 00:21:50,930
on the other hand uh we have the

486
00:21:55,190 --> 00:21:53,100
supermassive black hole that is at the

487
00:21:58,549 --> 00:21:55,200
center of most of these galaxies and

488
00:22:01,610 --> 00:21:58,559

they are enormous so this is a two-scale

489
00:22:03,890 --> 00:22:01,620
representation of Sagittarius A star

490
00:22:05,750 --> 00:22:03,900
Sagittarius A star again is the black

491
00:22:08,090 --> 00:22:05,760
hole at the center of our galaxy The

492
00:22:11,390 --> 00:22:08,100
Milky Way and the amount of mass that's

493
00:22:14,810 --> 00:22:11,400
inside of this black hole is more than 4

494
00:22:17,029 --> 00:22:14,820
million times that of the Sun so that's

495
00:22:19,789 --> 00:22:17,039
a huge number and so it's very

496
00:22:22,250 --> 00:22:19,799
surprising then to me that the diameter

497
00:22:25,909 --> 00:22:22,260
of this black hole is only going to be

498
00:22:27,770 --> 00:22:25,919
about 18 of the sizes of the sun

499
00:22:30,110 --> 00:22:27,780
um in diameter so you could stack 18

500
00:22:33,169 --> 00:22:30,120
Suns end to end and that would be the

501
00:22:36,110 --> 00:22:33,179
the diameter of this supermassive black

502
00:22:38,090 --> 00:22:36,120
hole so uh this just gives you both of

503
00:22:40,970 --> 00:22:38,100
these the Stellar Mass black hole and

504
00:22:43,549 --> 00:22:40,980
the supermassive black hole they both

505
00:22:46,190 --> 00:22:43,559
are represented of a very compact

506
00:22:47,510 --> 00:22:46,200
objects that exist in the universe and

507
00:22:50,390 --> 00:22:47,520
to bring it back to the Stellar Mass

508
00:22:53,210 --> 00:22:50,400
black hole just for comparison size here

509
00:22:55,430 --> 00:22:53,220
is the size of Earth right there I had a

510
00:22:57,409 --> 00:22:55,440
flashing pixel down down there that's

511
00:22:59,750 --> 00:22:57,419
the size of Earth in comparison to the

512
00:23:01,549 --> 00:22:59,760
Sun and in comparison to Sagittarius A

513
00:23:03,770 --> 00:23:01,559

star so when we talk about Stellar Mass

514
00:23:07,070 --> 00:23:03,780
black holes and supermassive black holes

515
00:23:09,230 --> 00:23:07,080
uh they are two completely far ends of

516
00:23:11,630 --> 00:23:09,240
the Spectrum in the uh the size and

517
00:23:16,430 --> 00:23:11,640
scope of these objects

518
00:23:18,409 --> 00:23:16,440
so uh the question that I most get as a

519
00:23:21,049 --> 00:23:18,419
astronomer as an astronomer that focuses

520
00:23:24,169 --> 00:23:21,059
on black holes in his career is our

521
00:23:26,450 --> 00:23:24,179
black holes dangerous like are they

522
00:23:28,130 --> 00:23:26,460
gonna hurt us should we be concerned

523
00:23:29,690 --> 00:23:28,140
about black holes

524
00:23:32,210 --> 00:23:29,700
and

525
00:23:34,370 --> 00:23:32,220
what I like to try to tell people is

526
00:23:36,529 --> 00:23:34,380
that well I mean

527
00:23:38,450 --> 00:23:36,539
you could swim with sharks

528
00:23:40,029 --> 00:23:38,460
but that'd be very dangerous instead

529
00:23:42,830 --> 00:23:40,039
maybe the best idea

530
00:23:44,690 --> 00:23:42,840
observe them from a safe distance inside

531
00:23:46,370 --> 00:23:44,700
of a cage and so that you're not even

532
00:23:48,350 --> 00:23:46,380
close to that shark

533
00:23:50,210 --> 00:23:48,360
um in the same vein

534
00:23:52,549 --> 00:23:50,220
uh you could observe you could look at a

535
00:23:54,049 --> 00:23:52,559
volcano laws erupting but if you're

536
00:23:55,850 --> 00:23:54,059
standing right next to a volcano while

537
00:23:57,890 --> 00:23:55,860
it's erupting you're going to have a bad

538
00:24:00,230 --> 00:23:57,900

time so instead what you're going to

539
00:24:02,990 --> 00:24:00,240
want to do is find a safe distance

540
00:24:04,909 --> 00:24:03,000
to observe that volcano and get all the

541
00:24:07,850 --> 00:24:04,919
information that you want while not

542
00:24:10,070 --> 00:24:07,860
being burned up from the volcano

543
00:24:11,690 --> 00:24:10,080
and then so uh if you see where I'm

544
00:24:14,510 --> 00:24:11,700
going with this

545
00:24:16,370 --> 00:24:14,520
um don't be near a black hole when

546
00:24:19,370 --> 00:24:16,380
you're trying to study it all right so

547
00:24:21,409 --> 00:24:19,380
black holes are dangerous objects if you

548
00:24:24,890 --> 00:24:21,419
go too close to them what we can do

549
00:24:26,690 --> 00:24:24,900
though is safely sit on our planet Earth

550
00:24:28,490 --> 00:24:26,700
and look at all of these black holes

551
00:24:30,350 --> 00:24:28,500
that are in space and none of them are

552
00:24:32,690 --> 00:24:30,360
going to bother us they are all at a

553
00:24:35,149 --> 00:24:32,700
very safe distance and viewing them from

554
00:24:37,250 --> 00:24:35,159
a remote location means that they're not

555
00:24:38,210 --> 00:24:37,260
going to bother us at all we're going to

556
00:24:41,330 --> 00:24:38,220
be okay

557
00:24:42,890 --> 00:24:41,340
so that maybe people think that their

558
00:24:44,810 --> 00:24:42,900
these black holes are dangerous because

559
00:24:46,010 --> 00:24:44,820
they think that they're vacuums and

560
00:24:47,570 --> 00:24:46,020
they're going to pull everything in but

561
00:24:49,430 --> 00:24:47,580
it's important to know that black holes

562
00:24:52,250 --> 00:24:49,440
don't suck all right

563
00:24:55,130 --> 00:24:52,260

so um what we could do as kind of like a

564
00:24:57,350 --> 00:24:55,140
thought experiment here is to just take

565
00:24:58,730 --> 00:24:57,360
this is a cartoon of our solar system as

566
00:25:00,590 --> 00:24:58,740
you can see there's the sun in the

567
00:25:03,529 --> 00:25:00,600
center and there's our eight planets

568
00:25:05,870 --> 00:25:03,539
that are surrounding it if we remove the

569
00:25:09,710 --> 00:25:05,880
Sun from our solar system and instead

570
00:25:12,110 --> 00:25:09,720
put in a black hole of equal Mass right

571
00:25:13,789 --> 00:25:12,120
so nothing has changed other than the

572
00:25:16,370 --> 00:25:13,799
sun has come out and a black hole of

573
00:25:17,870 --> 00:25:16,380
equal Mass has meant in its place then

574
00:25:20,090 --> 00:25:17,880
all of the planets are going to continue

575
00:25:21,649 --> 00:25:20,100
orbiting around that black hole as if

576
00:25:25,250 --> 00:25:21,659
nothing happened so they're going to be

577
00:25:26,810 --> 00:25:25,260
happily just orbiting around and since

578
00:25:28,970 --> 00:25:26,820
there's no change in mass at the center

579
00:25:31,130 --> 00:25:28,980
of the solar system uh nothing's going

580
00:25:34,250 --> 00:25:31,140
to be affected in how the orbits

581
00:25:35,930 --> 00:25:34,260
progress although it is true that we are

582
00:25:38,269 --> 00:25:35,940
removing all of the heat that's coming

583
00:25:40,250 --> 00:25:38,279
from the Sun so we're going to have our

584
00:25:42,409 --> 00:25:40,260
own set of problems because there's no

585
00:25:43,990 --> 00:25:42,419
sunlight that's the problem for a

586
00:25:45,649 --> 00:25:44,000
different day

587
00:25:49,610 --> 00:25:45,659
so

588
00:25:51,289 --> 00:25:49,620

um why do black holes then not like

589
00:25:53,990 --> 00:25:51,299
people think that they they suck because

590
00:25:55,909 --> 00:25:54,000
they don't uh emit any photons they're

591
00:25:58,490 --> 00:25:55,919
sucking in even light light can't escape

592
00:26:01,070 --> 00:25:58,500
how does that work and so what I try to

593
00:26:03,169 --> 00:26:01,080
explain that I think about

594
00:26:05,570 --> 00:26:03,179
um a rocket ship and how we try to take

595
00:26:08,750 --> 00:26:05,580
a rocket ship and leave uh the surface

596
00:26:11,330 --> 00:26:08,760
of the Earth all right so here's a very

597
00:26:13,850 --> 00:26:11,340
um basic equation uh where we're just

598
00:26:16,370 --> 00:26:13,860
saying if we try to calculate

599
00:26:18,769 --> 00:26:16,380
the velocity requires to escape the

600
00:26:20,510 --> 00:26:18,779
surface of something we essentially just

601
00:26:23,149 --> 00:26:20,520
need to know the mass of the object

602
00:26:25,370 --> 00:26:23,159
we're trying to escape and also the

603
00:26:28,850 --> 00:26:25,380
distance from the center of that object

604
00:26:30,890 --> 00:26:28,860
so to calculate the escape Velocity uh

605
00:26:33,710 --> 00:26:30,900
if you leave Earth we would just have

606
00:26:37,010 --> 00:26:33,720
the mass of Earth and we divide that by

607
00:26:38,930 --> 00:26:37,020
the the radius of Earth and if we do

608
00:26:40,549 --> 00:26:38,940
that calculation we can see that the

609
00:26:43,190 --> 00:26:40,559
velocity we're that's going to be

610
00:26:45,769 --> 00:26:43,200
required to leave Earth is about 11.2

611
00:26:47,930 --> 00:26:45,779
kilometers per second and I don't know

612
00:26:50,269 --> 00:26:47,940
how fast that is if you ask me to try to

613
00:26:53,269 --> 00:26:50,279

figure out how fast 11.2 kilometers per

614
00:26:56,029 --> 00:26:53,279
second is but we can just say that's how

615
00:26:57,289 --> 00:26:56,039
fast the rocket goes because Rockets

616
00:26:59,390 --> 00:26:57,299
have to be

617
00:27:02,330 --> 00:26:59,400
um reaching this velocity to be able to

618
00:27:05,450 --> 00:27:02,340
escape the gravitational pull of Earth

619
00:27:07,789 --> 00:27:05,460
and to be specific uh a Rocket's not

620
00:27:10,250 --> 00:27:07,799
actually going that velocity it's going

621
00:27:12,409 --> 00:27:10,260
a little bit slower than 11.2 kilometers

622
00:27:14,930 --> 00:27:12,419
per second because we're not trying to

623
00:27:17,870 --> 00:27:14,940
leave Earth's gravitational pull forever

624
00:27:20,090 --> 00:27:17,880
so if you're trying to maybe send a like

625
00:27:22,430 --> 00:27:20,100
a spaceship to another solar system

626
00:27:24,169 --> 00:27:22,440
another Stellar system some exoplanets

627
00:27:26,330 --> 00:27:24,179
or something then we would want to be

628
00:27:28,190 --> 00:27:26,340
going at least 11.2 kilometers per

629
00:27:30,169 --> 00:27:28,200
second but we don't necessarily need to

630
00:27:31,789 --> 00:27:30,179
do that to send something up to like the

631
00:27:33,289 --> 00:27:31,799
moon for instance

632
00:27:34,730 --> 00:27:33,299
so

633
00:27:36,529 --> 00:27:34,740
um that's what escape velocity is for

634
00:27:38,269 --> 00:27:36,539
Earth let's try to think about what

635
00:27:41,330 --> 00:27:38,279
would happen then if we turned Earth

636
00:27:44,149 --> 00:27:41,340
into an earth Mass black hole all right

637
00:27:46,909 --> 00:27:44,159
so the equation stays the same the mass

638
00:27:49,010 --> 00:27:46,919

of Earth stays the same but the distance

639
00:27:50,990 --> 00:27:49,020
that we're using from the center now is

640
00:27:54,169 --> 00:27:51,000
going to be approximately the radius of

641
00:27:56,450 --> 00:27:54,179
a ping pong ball that's how uh large a

642
00:27:59,450 --> 00:27:56,460
black hole would be if it was the uh the

643
00:28:01,909 --> 00:27:59,460
mass of Earth and so if we plug in that

644
00:28:03,710 --> 00:28:01,919
radius for our calculation the required

645
00:28:05,990 --> 00:28:03,720
velocity to escape the black hole is a

646
00:28:08,210 --> 00:28:06,000
trillion kilometers per second again

647
00:28:10,130 --> 00:28:08,220
another number that makes no sense to me

648
00:28:11,990 --> 00:28:10,140
but you can kind of think of it in the

649
00:28:15,529 --> 00:28:12,000
way of comparing to the speed of light

650
00:28:18,590 --> 00:28:15,539
because this is 3 000 times the speed of

651
00:28:20,810 --> 00:28:18,600
light and so therefore that's impossible

652
00:28:23,510 --> 00:28:20,820
like the fastest thing that we know of

653
00:28:25,669 --> 00:28:23,520
in the universe is the photon is the

654
00:28:27,289 --> 00:28:25,679
light particle that is traveling the

655
00:28:30,169 --> 00:28:27,299
speed of light nothing can go faster

656
00:28:33,169 --> 00:28:30,179
than than that so if you have a rocket

657
00:28:34,430 --> 00:28:33,179
on the surface of that black hole it's

658
00:28:35,990 --> 00:28:34,440
not going to leave because there's

659
00:28:37,669 --> 00:28:36,000
nothing that goes that fast even though

660
00:28:41,090 --> 00:28:37,679
the rockets that the photons live in

661
00:28:43,190 --> 00:28:41,100
cannot travel fast enough to escape uh

662
00:28:46,490 --> 00:28:43,200
the gravitational pull of the black hole

663
00:28:49,370 --> 00:28:46,500

and that's why photons are not escaping

664
00:28:52,250 --> 00:28:49,380
from from black holes

665
00:28:55,490 --> 00:28:52,260
so black holes themselves aren't that

666
00:28:57,830 --> 00:28:55,500
scary however when you have stuff coming

667
00:28:59,750 --> 00:28:57,840
in on a collision course

668
00:29:01,610 --> 00:28:59,760
um you're going to have a bad time so

669
00:29:04,250 --> 00:29:01,620
when here's an example of a star that's

670
00:29:07,010 --> 00:29:04,260
getting too close to a black hole and

671
00:29:09,350 --> 00:29:07,020
it's getting pulled apart shredded and

672
00:29:11,690 --> 00:29:09,360
you have all of this debris forming

673
00:29:13,250 --> 00:29:11,700
around the black holes parts of it are

674
00:29:15,950 --> 00:29:13,260
strewn around but they're coming back

675
00:29:17,930 --> 00:29:15,960
they're going to be coming in to form a

676
00:29:21,049 --> 00:29:17,940
sort of a disc of debris that's

677
00:29:23,570 --> 00:29:21,059
surrounding this black hole and so when

678
00:29:25,909 --> 00:29:23,580
we create these debris discs astronomers

679
00:29:29,930 --> 00:29:25,919
call this kind of disk an accretion disk

680
00:29:32,450 --> 00:29:29,940
so accretion is a word for like eating

681
00:29:34,909 --> 00:29:32,460
um and so the black hole is eating this

682
00:29:37,010 --> 00:29:34,919
matter from the star or from a gas lane

683
00:29:38,510 --> 00:29:37,020
or whatever and it starts spinning

684
00:29:39,889 --> 00:29:38,520
around the black hole and as it's

685
00:29:42,230 --> 00:29:39,899
spinning around that black hole it's

686
00:29:44,389 --> 00:29:42,240
spiraling down the drain it's heating up

687
00:29:46,190 --> 00:29:44,399
so if you rub your hands together your

688
00:29:48,950 --> 00:29:46,200

hands get warm and so you can imagine

689
00:29:50,450 --> 00:29:48,960
that the dust and the gas and the debris

690
00:29:52,490 --> 00:29:50,460
that's spitting around this black hole

691
00:29:55,310 --> 00:29:52,500
is rubbing its hands together so fast

692
00:29:59,269 --> 00:29:55,320
that it doesn't produce just Heats but

693
00:30:01,909 --> 00:29:59,279
also UV rays x-rays gamma rays to a

694
00:30:04,850 --> 00:30:01,919
flood of radiation and so when we have

695
00:30:06,889 --> 00:30:04,860
this situation go on around a

696
00:30:09,470 --> 00:30:06,899
supermassive black hole at the center of

697
00:30:12,350 --> 00:30:09,480
a galaxy we form an event which is

698
00:30:15,169 --> 00:30:12,360
called an active Galactic nucleus and

699
00:30:19,730 --> 00:30:15,179
for short we just call that an AGN

700
00:30:22,010 --> 00:30:19,740
and AGN are uh the monsters then the the

701
00:30:24,350 --> 00:30:22,020
giant dumpster fires that we're trying

702
00:30:26,210 --> 00:30:24,360
to understand that are wrecking the

703
00:30:27,889 --> 00:30:26,220
environments that they live in

704
00:30:30,529 --> 00:30:27,899
so

705
00:30:32,510 --> 00:30:30,539
um all of that UV and X-ray and gamma

706
00:30:34,669 --> 00:30:32,520
ray radiation is flooding out from

707
00:30:37,789 --> 00:30:34,679
around this accretion disk

708
00:30:40,010 --> 00:30:37,799
um and they're extremely energetic so

709
00:30:43,850 --> 00:30:40,020
what can we do like I tried to come up

710
00:30:46,190 --> 00:30:43,860
with a way to again quantify the amount

711
00:30:47,269 --> 00:30:46,200
of energy that's coming out from an

712
00:30:49,850 --> 00:30:47,279
average

713
00:30:52,250 --> 00:30:49,860

um or even like a low end supermassive

714
00:30:55,190 --> 00:30:52,260
black hole so I I did a calculation for

715
00:30:56,870 --> 00:30:55,200
like one of my my favorite nearby lower

716
00:30:58,610 --> 00:30:56,880
Luminosity

717
00:31:00,950 --> 00:30:58,620
um supermassive black holes the active

718
00:31:04,010 --> 00:31:00,960
galaxies and I figured okay you have an

719
00:31:05,870 --> 00:31:04,020
atomic bomb that makes sense so let's

720
00:31:07,970 --> 00:31:05,880
have how many atomic bombs do we need

721
00:31:10,730 --> 00:31:07,980
and so it turns out that if you took an

722
00:31:12,950 --> 00:31:10,740
atomic bomb for every grain of sand on

723
00:31:15,470 --> 00:31:12,960
earth and you detonated it at the same

724
00:31:16,909 --> 00:31:15,480
time that's not enough you're not going

725
00:31:19,850 --> 00:31:16,919
to create even close to what you need

726
00:31:22,610 --> 00:31:19,860
from uh to create the energy coming from

727
00:31:26,769 --> 00:31:22,620
an AGN instead what you need to do is

728
00:31:30,950 --> 00:31:26,779
create a hundred and sixty thousand

729
00:31:32,990 --> 00:31:30,960
Earths and duplicate them to get all of

730
00:31:36,409 --> 00:31:33,000
the sand from those Earths and then turn

731
00:31:38,510 --> 00:31:36,419
all of that sand into atomic bombs and

732
00:31:40,370 --> 00:31:38,520
if you detonate all of that at the same

733
00:31:44,350 --> 00:31:40,380
time then you're creating the energy

734
00:31:47,149 --> 00:31:44,360
that's coming from a AGN uh per second

735
00:31:49,970 --> 00:31:47,159
so the amount of energy that's coming

736
00:31:53,269 --> 00:31:49,980
out of these things is enormous it's

737
00:31:55,370 --> 00:31:53,279
just crazy big and so the question then

738
00:31:58,549 --> 00:31:55,380

is if there's all of this energy that's

739
00:32:00,710 --> 00:31:58,559
coming from this very small object and

740
00:32:03,950 --> 00:32:00,720
the accretion disk surrounding it like

741
00:32:06,110 --> 00:32:03,960
uh what does that energy do

742
00:32:08,029 --> 00:32:06,120
and so

743
00:32:11,330 --> 00:32:08,039
um to come up with a kind of a

744
00:32:14,090 --> 00:32:11,340
comparison uh like with some thing that

745
00:32:16,549 --> 00:32:14,100
is not necessarily astronomy related I

746
00:32:19,130 --> 00:32:16,559
was watching the show uh Chernobyl and

747
00:32:22,669 --> 00:32:19,140
so this is a show on HBO uh spoiler

748
00:32:24,590 --> 00:32:22,679
alert Chernobyl explodes and so there

749
00:32:27,049 --> 00:32:24,600
there's a scene where there's a lot of

750
00:32:28,549 --> 00:32:27,059
folks watching from a great distance uh

751
00:32:29,690 --> 00:32:28,559
and they're looking at the explosion and

752
00:32:31,730 --> 00:32:29,700
they can see that there's this bright

753
00:32:34,970 --> 00:32:31,740
blue beam of light that's shooting up

754
00:32:36,889 --> 00:32:34,980
from the um where the disaster is

755
00:32:38,690 --> 00:32:36,899
happening and they're saying wow it's so

756
00:32:40,730 --> 00:32:38,700
beautiful and so what's happening in

757
00:32:43,310 --> 00:32:40,740
this situation is that the radiation

758
00:32:46,130 --> 00:32:43,320
that's coming from the reactor meltdown

759
00:32:48,529 --> 00:32:46,140
is flooding up into the atmosphere and

760
00:32:51,590 --> 00:32:48,539
it's frying the air molecules either

761
00:32:53,330 --> 00:32:51,600
it's stripping electrons off of the air

762
00:32:56,210 --> 00:32:53,340
the atoms that are up there and it's

763
00:32:59,450 --> 00:32:56,220

called ionization and so uh I'm pretty

764
00:33:01,430 --> 00:32:59,460
sure it's blue then because the most gas

765
00:33:04,190 --> 00:33:01,440
that is in our atmosphere is nitrogen

766
00:33:05,990 --> 00:33:04,200
and so the blue color is coming from the

767
00:33:08,029 --> 00:33:06,000
majority of the gas being nitrogen and

768
00:33:09,529 --> 00:33:08,039
that's the color that is well it's going

769
00:33:12,830 --> 00:33:09,539
to be it's gonna be most dominant in the

770
00:33:15,649 --> 00:33:12,840
ionized gas of our atmosphere so you can

771
00:33:18,169 --> 00:33:15,659
see then or have an idea that the only

772
00:33:21,590 --> 00:33:18,179
way you can create this this glowing gas

773
00:33:23,930 --> 00:33:21,600
is if you expose that gas to an enormous

774
00:33:28,549 --> 00:33:23,940
source of radiation

775
00:33:31,370 --> 00:33:28,559
so we see then a similar process

776
00:33:32,330 --> 00:33:31,380
um happening in all of the AGM that we

777
00:33:36,049 --> 00:33:32,340
look at

778
00:33:38,750 --> 00:33:36,059
so here's a nearby active Galaxy uh and

779
00:33:40,190 --> 00:33:38,760
we can zoom in to where the the nucleus

780
00:33:42,470 --> 00:33:40,200
is

781
00:33:46,970 --> 00:33:42,480
um and so we can take a and so

782
00:33:49,730 --> 00:33:46,980
um here is then a picture using the uh

783
00:33:51,289 --> 00:33:49,740
Muse Cube Muse field so this is what

784
00:33:53,870 --> 00:33:51,299
Frank was talking about earlier this

785
00:33:56,750 --> 00:33:53,880
cutout is the muse field uh for this

786
00:33:59,990 --> 00:33:56,760
specific Galaxy and then we can look at

787
00:34:02,210 --> 00:34:00,000
the individual uh colors of the ionized

788
00:34:04,970 --> 00:34:02,220

gas the fry gas in here to kind of see

789
00:34:07,130 --> 00:34:04,980
the impact that the AGN is having on its

790
00:34:09,589 --> 00:34:07,140
host Galaxy so when we turn that filter

791
00:34:13,190 --> 00:34:09,599
on we can see that there's this really

792
00:34:15,349 --> 00:34:13,200
beautiful biconical or hourglass shape

793
00:34:17,270 --> 00:34:15,359
that's happening here and this is the

794
00:34:20,149 --> 00:34:17,280
due to the same process where you're

795
00:34:22,609 --> 00:34:20,159
having radiation coming from that

796
00:34:26,030 --> 00:34:22,619
Central black hole flooding out into the

797
00:34:27,589 --> 00:34:26,040
system and uh frying that gas so here's

798
00:34:29,810 --> 00:34:27,599
kind of a cartoon that I helped put

799
00:34:32,270 --> 00:34:29,820
together at Goddard

800
00:34:34,909 --> 00:34:32,280
um where yeah so the the AGN is shining

801
00:34:37,550 --> 00:34:34,919
out into the host disk and it's kind of

802
00:34:39,290 --> 00:34:37,560
acting like a flashlight of Doom where

803
00:34:42,050 --> 00:34:39,300
all of the radiation that's coming out

804
00:34:43,849 --> 00:34:42,060
from the the central engine is frying

805
00:34:45,950 --> 00:34:43,859
anything in its path that it runs into

806
00:34:49,129 --> 00:34:45,960
and so that's what you're producing then

807
00:34:51,950 --> 00:34:49,139
you're kind of producing uh this this

808
00:34:54,169 --> 00:34:51,960
flashlight effect of where all the gas

809
00:34:56,570 --> 00:34:54,179
that's being impacted by the radiation

810
00:34:59,750 --> 00:34:56,580
from the central engine so we can also

811
00:35:02,750 --> 00:34:59,760
kind of uh figure out the impact uh of

812
00:35:05,270 --> 00:35:02,760
that radiation if we look at the what we

813
00:35:07,910 --> 00:35:05,280

call the kinematics of that gas using

814
00:35:10,370 --> 00:35:07,920
this Muse ifu data Cube where we're

815
00:35:13,370 --> 00:35:10,380
having Imaging but also Spectra so to

816
00:35:14,870 --> 00:35:13,380
just um talk about how we analyze that

817
00:35:16,430 --> 00:35:14,880
data we're just going to step into

818
00:35:18,950 --> 00:35:16,440
talking about the Doppler effect real

819
00:35:22,490 --> 00:35:18,960
quick so the Doppler effect is where you

820
00:35:24,710 --> 00:35:22,500
have a shift of a frequency due to some

821
00:35:26,810 --> 00:35:24,720
sort of velocity occurring so we have an

822
00:35:28,910 --> 00:35:26,820
ambulance in this example the ambulance

823
00:35:31,310 --> 00:35:28,920
is making a noise the ambulance is not

824
00:35:33,230 --> 00:35:31,320
moving anywhere so the sound that is

825
00:35:34,849 --> 00:35:33,240
heard by the people in front and behind

826
00:35:36,010 --> 00:35:34,859
the ambulance is going to be the same

827
00:35:38,770 --> 00:35:36,020
frequency

828
00:35:41,630 --> 00:35:38,780
alternatively if you have that ambulance

829
00:35:43,910 --> 00:35:41,640
traveling at a specific velocity the

830
00:35:46,130 --> 00:35:43,920
wavelengths in front of the ambulance

831
00:35:48,589 --> 00:35:46,140
are going to be squished together and

832
00:35:51,650 --> 00:35:48,599
create a higher frequency whereas the

833
00:35:53,690 --> 00:35:51,660
way the wavelengths behind the ambulance

834
00:35:57,230 --> 00:35:53,700
are going to be stretched apart creating

835
00:35:58,550 --> 00:35:57,240
a lower frequency so the best way to do

836
00:36:00,190 --> 00:35:58,560
it is just think about like a race car

837
00:36:02,569 --> 00:36:00,200
coming towards you

838
00:36:04,490 --> 00:36:02,579

right so it's a higher pitched sound

839
00:36:07,550 --> 00:36:04,500
coming towards you lower pitch sound

840
00:36:10,190 --> 00:36:07,560
going away and so we can apply that same

841
00:36:12,050 --> 00:36:10,200
effect with light

842
00:36:14,870 --> 00:36:12,060
so if we have a light bulb and the light

843
00:36:17,630 --> 00:36:14,880
bulb is giving off photons if that light

844
00:36:19,010 --> 00:36:17,640
bulb isn't moving anywhere the photons

845
00:36:20,990 --> 00:36:19,020
that we're seeing on either end are

846
00:36:23,390 --> 00:36:21,000
going to be the same wavelength and I'm

847
00:36:25,670 --> 00:36:23,400
saying green for this example but if we

848
00:36:28,250 --> 00:36:25,680
have that light bulb uh having a

849
00:36:30,170 --> 00:36:28,260
specific velocity uh the wavelengths

850
00:36:32,750 --> 00:36:30,180
then gets squished together or spread

851
00:36:35,569 --> 00:36:32,760
out and so if it's squished together we

852
00:36:37,970 --> 00:36:35,579
see a Bluer wavelength and if it's

853
00:36:40,849 --> 00:36:37,980
stretched out we see a redder wavelength

854
00:36:42,530 --> 00:36:40,859
and so these are called Blue shifts when

855
00:36:44,630 --> 00:36:42,540
the light becomes Bluer it's shifted

856
00:36:46,310 --> 00:36:44,640
toward the blue end of the spectrum and

857
00:36:48,890 --> 00:36:46,320
when it's traveling and being spread out

858
00:36:50,569 --> 00:36:48,900
we call that the red shift or it's being

859
00:36:51,770 --> 00:36:50,579
shifted into the redder end of the

860
00:36:55,130 --> 00:36:51,780
spectrum

861
00:36:57,829 --> 00:36:55,140
okay so we can use that idea of blue

862
00:36:59,630 --> 00:36:57,839
shifts and redshifts um to equip

863
00:37:01,609 --> 00:36:59,640

ourselves to understand the data that

864
00:37:04,430 --> 00:37:01,619
we're going to look at right now then so

865
00:37:07,010 --> 00:37:04,440
we go back to our Muse cube of this

866
00:37:10,069 --> 00:37:07,020
active Galaxy and we can look at the

867
00:37:13,250 --> 00:37:10,079
velocity of the gas and we see that most

868
00:37:16,670 --> 00:37:13,260
of the gas here is orbiting the center

869
00:37:18,650 --> 00:37:16,680
of the Galaxy so what overall this is is

870
00:37:21,770 --> 00:37:18,660
a big rotating

871
00:37:24,349 --> 00:37:21,780
um bike wheel if you will so that the

872
00:37:26,990 --> 00:37:24,359
bottom right hand field is rotating

873
00:37:30,170 --> 00:37:27,000
towards us and then the upper left hand

874
00:37:32,569 --> 00:37:30,180
corner is excuse me rotating away from

875
00:37:34,790 --> 00:37:32,579
us so the the foreground of the Galaxy

876
00:37:37,010 --> 00:37:34,800
is to the bottom left and then the

877
00:37:40,310 --> 00:37:37,020
background of the Galaxy is to the upper

878
00:37:42,170 --> 00:37:40,320
right so this is most of the gas that's

879
00:37:45,109 --> 00:37:42,180
happening in the Galaxy this is gas that

880
00:37:46,849 --> 00:37:45,119
is maybe attributed to stars that are in

881
00:37:49,849 --> 00:37:46,859
the host plane that are rotating around

882
00:37:52,430 --> 00:37:49,859
but then we can also isolate just what

883
00:37:55,550 --> 00:37:52,440
the ionized gas is doing the gas that is

884
00:37:57,109 --> 00:37:55,560
being died by the active Galaxy and we

885
00:38:00,349 --> 00:37:57,119
can see what's happening with those

886
00:38:05,089 --> 00:38:00,359
kinematics as well and so we see then

887
00:38:08,390 --> 00:38:05,099
here the AGN is driving the ionized gas

888
00:38:11,569 --> 00:38:08,400

out of the Galaxy so instead of our

889
00:38:13,430 --> 00:38:11,579
rotation curve here now what we have is

890
00:38:15,829 --> 00:38:13,440
a radial motion which means it's going

891
00:38:19,370 --> 00:38:15,839
from the center traveling out like along

892
00:38:21,290 --> 00:38:19,380
a radius or a spoke and in a wheel and

893
00:38:23,630 --> 00:38:21,300
so you can see that the gas the fried

894
00:38:26,810 --> 00:38:23,640
gas in the upper right hand corner is

895
00:38:30,349 --> 00:38:26,820
being driven toward us uh and then the

896
00:38:32,630 --> 00:38:30,359
gas in the bottom left is being is red

897
00:38:35,329 --> 00:38:32,640
shifted and being driven away from us so

898
00:38:37,490 --> 00:38:35,339
what you kind of have Happening Here is

899
00:38:40,370 --> 00:38:37,500
the flashlight is running into that

900
00:38:42,410 --> 00:38:40,380
plane of the Galaxy and then the gas is

901
00:38:44,569 --> 00:38:42,420
running into that and then kind of

902
00:38:47,150 --> 00:38:44,579
hitting a dense patch and maybe popping

903
00:38:49,130 --> 00:38:47,160
up uh and splashing upwards so you guys

904
00:38:51,230 --> 00:38:49,140
can maybe think about like that movie

905
00:38:53,870 --> 00:38:51,240
with The Little Mermaid and she's on the

906
00:38:56,390 --> 00:38:53,880
Rock and she's singing and the wave

907
00:38:58,609 --> 00:38:56,400
comes crashing up behind her

908
00:39:01,910 --> 00:38:58,619
um because the wave has hit that hard

909
00:39:03,710 --> 00:39:01,920
dense medium and is splashing up uh to

910
00:39:06,470 --> 00:39:03,720
create that

911
00:39:08,270 --> 00:39:06,480
um that displacement out of the plane

912
00:39:11,510 --> 00:39:08,280
and so that's what we're kind of seeing

913
00:39:13,069 --> 00:39:11,520

then with this gas being driven out of

914
00:39:14,329 --> 00:39:13,079
the plane of the Galaxy

915
00:39:15,530 --> 00:39:14,339
and so

916
00:39:18,170 --> 00:39:15,540
um

917
00:39:20,750 --> 00:39:18,180
besides also noticing what the redshift

918
00:39:23,630 --> 00:39:20,760
and blue shift of the Galaxy uh the gas

919
00:39:27,109 --> 00:39:23,640
is we can actually measure the velocity

920
00:39:29,329 --> 00:39:27,119
of this gas and so when we look at how

921
00:39:31,609 --> 00:39:29,339
much how red shifted or blue shifted

922
00:39:34,790 --> 00:39:31,619
that gas is we can measure that the gas

923
00:39:37,430 --> 00:39:34,800
is traveling roughly 300 kilometers per

924
00:39:38,870 --> 00:39:37,440
second and typically it can be greater

925
00:39:41,290 --> 00:39:38,880
than that and so what that really

926
00:39:44,450 --> 00:39:41,300
converts to another giant number it's

927
00:39:47,390 --> 00:39:44,460
670 miles an hour but

928
00:39:49,390 --> 00:39:47,400
um more for my human brain it's like

929
00:39:52,069 --> 00:39:49,400
you're traveling from Seattle to Miami

930
00:39:54,109 --> 00:39:52,079
along roads hoping there's no traffic

931
00:39:57,109 --> 00:39:54,119
and you're going to arrive there in a

932
00:40:01,069 --> 00:39:57,119
little under 18 seconds so you can kind

933
00:40:03,530 --> 00:40:01,079
of Imagine then that this gas is not

934
00:40:05,450 --> 00:40:03,540
very pleasant it's ionized it's it's

935
00:40:08,030 --> 00:40:05,460
frying the heck out of whatever it's the

936
00:40:10,010 --> 00:40:08,040
touching the radiation is and then it's

937
00:40:13,190 --> 00:40:10,020
also sweeping everything up and driving

938
00:40:14,690 --> 00:40:13,200

it out uh at bullet train speeds faster

939
00:40:15,890 --> 00:40:14,700
than bullet train right it's 18 seconds

940
00:40:17,089 --> 00:40:15,900
it's crazy

941
00:40:21,829 --> 00:40:17,099
so

942
00:40:23,750 --> 00:40:21,839
these monsters then is that you see

943
00:40:25,310 --> 00:40:23,760
these beautiful pictures that we're

944
00:40:27,710 --> 00:40:25,320
always looking at in this ionized gas

945
00:40:30,230 --> 00:40:27,720
and it's very similar to me as looking

946
00:40:32,030 --> 00:40:30,240
at hurricanes from space and you're

947
00:40:34,250 --> 00:40:32,040
looking at them and you're saying Wow

948
00:40:37,010 --> 00:40:34,260
nature is glorious nature is beautiful

949
00:40:40,490 --> 00:40:37,020
but then if you're living in that

950
00:40:41,630 --> 00:40:40,500
hurricane it is the worst so the same

951
00:40:44,329 --> 00:40:41,640
thing would be happening if we're living

952
00:40:45,890 --> 00:40:44,339
in an active Galaxy there's tons of

953
00:40:48,710 --> 00:40:45,900
radiation that would be pelting our

954
00:40:50,329 --> 00:40:48,720
atmosphere and lots of winds that are

955
00:40:52,310 --> 00:40:50,339
traveling and blowing everything away

956
00:40:55,790 --> 00:40:52,320
and blowing our atmosphere probably away

957
00:40:57,950 --> 00:40:55,800
so we'd be having just the worst time if

958
00:41:00,109 --> 00:40:57,960
we're living in this beautiful light

959
00:41:03,530 --> 00:41:00,119
Echo that we're seeing in these galaxies

960
00:41:07,670 --> 00:41:03,540
so this is why we consider them the

961
00:41:10,910 --> 00:41:07,680
monsters of the universe that they are

962
00:41:13,430 --> 00:41:10,920
so the question then is these things

963
00:41:15,170 --> 00:41:13,440

well we've confirmed I I believe that

964
00:41:17,510 --> 00:41:15,180
these are monsters

965
00:41:19,970 --> 00:41:17,520
um and so how do these AGN affect their

966
00:41:22,250 --> 00:41:19,980
galaxies and we're still trying to

967
00:41:23,990 --> 00:41:22,260
figure that out right so I mean we have

968
00:41:26,450 --> 00:41:24,000
a general understanding of what's going

969
00:41:28,430 --> 00:41:26,460
on here but we're not really sure how

970
00:41:31,490 --> 00:41:28,440
it's impacting the host galaxies what

971
00:41:34,190 --> 00:41:31,500
kind of effects does this have and so um

972
00:41:36,410 --> 00:41:34,200
to try to understand how it's affecting

973
00:41:38,690 --> 00:41:36,420
a Galaxy we need to know how stars form

974
00:41:40,849 --> 00:41:38,700
in a galaxy so here's a picture of the

975
00:41:44,810 --> 00:41:40,859
Orion Nebula and we're doing a fly

976
00:41:46,670 --> 00:41:44,820
through of a video that was created

977
00:41:49,310 --> 00:41:46,680
um to kind of simulate what the Orion

978
00:41:51,349 --> 00:41:49,320
Nebula looks like and as we're traveling

979
00:41:54,770 --> 00:41:51,359
through we can see that all of this gas

980
00:41:56,750 --> 00:41:54,780
has formed on itself and compressed down

981
00:41:59,810 --> 00:41:56,760
and when you have enough gas it's going

982
00:42:01,490 --> 00:41:59,820
to ignite the fusion into stars and you

983
00:42:04,670 --> 00:42:01,500
form all of these Stars which eventually

984
00:42:07,069 --> 00:42:04,680
blow away the Cocoon of of gas to reveal

985
00:42:10,670 --> 00:42:07,079
themselves but the point here is that

986
00:42:16,010 --> 00:42:10,680
you need all of this gas to form stars

987
00:42:19,790 --> 00:42:16,020
in a galaxy so uh AGN then kind of

988
00:42:22,790 --> 00:42:19,800

affects how stars form all right because

989
00:42:26,930 --> 00:42:22,800
the winds are interacting with that star

990
00:42:30,710 --> 00:42:26,940
farming material so the way that I

991
00:42:34,010 --> 00:42:30,720
connect what's happening in a Galaxy to

992
00:42:36,349 --> 00:42:34,020
my brain is then by trying to compare it

993
00:42:39,589 --> 00:42:36,359
to maybe what the um

994
00:42:41,089 --> 00:42:39,599
the the physics that you see in a sink

995
00:42:42,530 --> 00:42:41,099
at home when you turn the faucet on

996
00:42:44,450 --> 00:42:42,540
right so you turn the faucet on

997
00:42:47,450 --> 00:42:44,460
sometimes you have this water that's

998
00:42:49,010 --> 00:42:47,460
hitting the bottom of the sink and uh it

999
00:42:51,470 --> 00:42:49,020
pushes it outward until you get to this

1000
00:42:54,530 --> 00:42:51,480
like ring this barrier where this

1001
00:42:55,730 --> 00:42:54,540
pressure Ridge or whatever and so uh

1002
00:42:58,609 --> 00:42:55,740
both of these

1003
00:43:02,089 --> 00:42:58,619
um both AGM and this faucet situation

1004
00:43:04,550 --> 00:43:02,099
have the two forms of feedback that I I

1005
00:43:06,829 --> 00:43:04,560
think are are important for us to try to

1006
00:43:10,490 --> 00:43:06,839
understand how galaxies evolve over time

1007
00:43:13,609 --> 00:43:10,500
the first one being that AGN can remove

1008
00:43:16,190 --> 00:43:13,619
gas at small radii to prevent star

1009
00:43:17,870 --> 00:43:16,200
formation so you have these winds that

1010
00:43:19,849 --> 00:43:17,880
are traveling the radiation is running

1011
00:43:23,750 --> 00:43:19,859
into the gas and it's pushing it outward

1012
00:43:26,450 --> 00:43:23,760
uh and removing any sort of uh gas that

1013
00:43:28,309 --> 00:43:26,460

exists at the small radii and that means

1014
00:43:29,990 --> 00:43:28,319
you're preventing

1015
00:43:31,670 --> 00:43:30,000
um future stars from forming because

1016
00:43:34,069 --> 00:43:31,680
you're removing the nurseries or you're

1017
00:43:36,470 --> 00:43:34,079
not allowing any gas to exist there from

1018
00:43:38,210 --> 00:43:36,480
Star which stars conform from and so

1019
00:43:41,210 --> 00:43:38,220
what we call this is a we call it a

1020
00:43:43,190 --> 00:43:41,220
negative uh feedback scenario where

1021
00:43:44,809 --> 00:43:43,200
we're removing the potential for Star

1022
00:43:48,410 --> 00:43:44,819
formation

1023
00:43:50,510 --> 00:43:48,420
um also at greater distances uh the wind

1024
00:43:53,329 --> 00:43:50,520
the driving effect is not going to be as

1025
00:43:55,970 --> 00:43:53,339
powerful in these uh galaxies and what

1026
00:43:58,849 --> 00:43:55,980
we are then seeing potentially is that

1027
00:44:01,430 --> 00:43:58,859
the gas is being pushed together and so

1028
00:44:04,670 --> 00:44:01,440
that is being compressed

1029
00:44:05,930 --> 00:44:04,680
um at greater radiant greater radii and

1030
00:44:08,690 --> 00:44:05,940
then when you're compressing the gas

1031
00:44:10,670 --> 00:44:08,700
you're kind of giving the Stellar

1032
00:44:12,410 --> 00:44:10,680
nurseries like a head start or pressing

1033
00:44:14,690 --> 00:44:12,420
like Fast Forward right because you're

1034
00:44:17,870 --> 00:44:14,700
pushing the gas together and making it

1035
00:44:20,809 --> 00:44:17,880
easier for those stars to form

1036
00:44:23,030 --> 00:44:20,819
um at later ethics so when you're then

1037
00:44:27,230 --> 00:44:23,040
promoting star formation this is called

1038
00:44:30,829 --> 00:44:27,240

a positive uh feedback situation

1039
00:44:32,690 --> 00:44:30,839
so um we're trying to understand both

1040
00:44:35,990 --> 00:44:32,700
the positive and the negative feedback

1041
00:44:37,670 --> 00:44:36,000
situations and we're going to be using

1042
00:44:39,770 --> 00:44:37,680
James Webb James Webb is fantastic for

1043
00:44:42,650 --> 00:44:39,780
revealing the New Dimensions or several

1044
00:44:44,450 --> 00:44:42,660
New Dimensions of agnostronomy

1045
00:44:46,430 --> 00:44:44,460
um and so we can just talk about real

1046
00:44:48,290 --> 00:44:46,440
quickly what those dimensions are but

1047
00:44:49,970 --> 00:44:48,300
Frank did a very nice job of uh

1048
00:44:52,309 --> 00:44:49,980
summarizing some of them earlier as well

1049
00:44:55,490 --> 00:44:52,319
so I might be repeating uh him a little

1050
00:44:58,250 --> 00:44:55,500
bit here but uh the first one is that

1051
00:45:00,410 --> 00:44:58,260
we're seeing a new dimension of space

1052
00:45:02,809 --> 00:45:00,420
all right so

1053
00:45:06,290 --> 00:45:02,819
um nearby galaxies if they're emitting

1054
00:45:09,050 --> 00:45:06,300
light in the optical we Hubble got you

1055
00:45:10,910 --> 00:45:09,060
Hubble can see that a mission from these

1056
00:45:14,089 --> 00:45:10,920
nearby active galaxies in the optical

1057
00:45:17,870 --> 00:45:14,099
and we've learned so so much about how

1058
00:45:19,609 --> 00:45:17,880
active galaxies regular galaxies

1059
00:45:22,970 --> 00:45:19,619
um anything in the nearby universe

1060
00:45:25,069 --> 00:45:22,980
happens to operate in the optical but as

1061
00:45:27,410 --> 00:45:25,079
you go to Greater distances away from

1062
00:45:30,890 --> 00:45:27,420
Earth the universe is always expanding

1063
00:45:32,750 --> 00:45:30,900

and again that Doppler shift comes into

1064
00:45:35,390 --> 00:45:32,760
play whereas everything is expanding

1065
00:45:37,730 --> 00:45:35,400
away from us that light that once was in

1066
00:45:40,550 --> 00:45:37,740
the optical is now shifted to the

1067
00:45:43,970 --> 00:45:40,560
infrared so we can't observe these more

1068
00:45:46,250 --> 00:45:43,980
distant galaxies in the same way with

1069
00:45:48,410 --> 00:45:46,260
Hubble as we're looking at the galaxies

1070
00:45:51,170 --> 00:45:48,420
in the nearby Universe we can't do a

1071
00:45:53,270 --> 00:45:51,180
one-to-one comparison so if we include

1072
00:45:55,430 --> 00:45:53,280
observations from the James Webb Space

1073
00:45:58,130 --> 00:45:55,440
Telescope we're now able to be more

1074
00:46:01,550 --> 00:45:58,140
sensitive to the infrared light that has

1075
00:46:03,770 --> 00:46:01,560
been redshifted and is representative of

1076
00:46:05,750 --> 00:46:03,780
the optical light that is coming from

1077
00:46:07,990 --> 00:46:05,760
the more nearby galaxies and now we're

1078
00:46:11,930 --> 00:46:08,000
able to have that one-to-one comparison

1079
00:46:14,329 --> 00:46:11,940
to see how do how does the universe

1080
00:46:16,670 --> 00:46:14,339
change from these greater distances to

1081
00:46:19,130 --> 00:46:16,680
the more nearby Universe well this one

1082
00:46:20,930 --> 00:46:19,140
has more emission of this hydrogen line

1083
00:46:23,569 --> 00:46:20,940
that we see

1084
00:46:25,609 --> 00:46:23,579
um then at the galaxies that are nearer

1085
00:46:27,470 --> 00:46:25,619
nearer to us right so we're able to make

1086
00:46:29,690 --> 00:46:27,480
this comparison

1087
00:46:32,750 --> 00:46:29,700
um between the optical nearby universe

1088
00:46:34,910 --> 00:46:32,760

and the infrared uh Universe at greater

1089
00:46:37,309 --> 00:46:34,920
distances

1090
00:46:39,109 --> 00:46:37,319
um additionally another dimension that

1091
00:46:41,809 --> 00:46:39,119
um James Webb provides us is just

1092
00:46:43,790 --> 00:46:41,819
wavelength space so this is uh also from

1093
00:46:46,609 --> 00:46:43,800
that fangs project

1094
00:46:48,770 --> 00:46:46,619
um showing this NGC 7469 and what we're

1095
00:46:50,450 --> 00:46:48,780
doing is we're blinking between the

1096
00:46:52,069 --> 00:46:50,460
optical and the Hubble Imaging and then

1097
00:46:55,069 --> 00:46:52,079
the glowing red

1098
00:46:57,530 --> 00:46:55,079
um here is the dust that's glowing in

1099
00:46:59,630 --> 00:46:57,540
the infrared so it's providing as Frank

1100
00:47:01,790 --> 00:46:59,640
had mentioned earlier this additional

1101
00:47:03,589 --> 00:47:01,800
Dimension to these galaxies so we

1102
00:47:06,109 --> 00:47:03,599
understand it in the optical light

1103
00:47:08,030 --> 00:47:06,119
what's happening with this ionized gas

1104
00:47:09,650 --> 00:47:08,040
what's happening with the light

1105
00:47:10,970 --> 00:47:09,660
um being from coming from the fried gas

1106
00:47:14,510 --> 00:47:10,980
but we have very little information

1107
00:47:16,790 --> 00:47:14,520
about the cold uh molecular gas that's

1108
00:47:18,589 --> 00:47:16,800
in these galaxies so with the infrared

1109
00:47:20,870 --> 00:47:18,599
light coming from uh James Webb

1110
00:47:23,390 --> 00:47:20,880
observations we're able to have more

1111
00:47:26,450 --> 00:47:23,400
puzzle pieces to put together to tell

1112
00:47:27,650 --> 00:47:26,460
that story to be what you guess I guess

1113
00:47:29,270 --> 00:47:27,660

you could be like a gumshoe or a

1114
00:47:30,650 --> 00:47:29,280
detective where you're Gathering all

1115
00:47:32,690 --> 00:47:30,660
these different clues for the same

1116
00:47:34,910 --> 00:47:32,700
Target using different wavelengths

1117
00:47:37,730 --> 00:47:34,920
different wave bands so you come up with

1118
00:47:39,230 --> 00:47:37,740
a coherent cohesive story of what's

1119
00:47:40,670 --> 00:47:39,240
happening in each of these nearby

1120
00:47:42,050 --> 00:47:40,680
galaxies

1121
00:47:43,490 --> 00:47:42,060
and then

1122
00:47:45,710 --> 00:47:43,500
um the other dimension that Hubble is

1123
00:47:47,630 --> 00:47:45,720
bringing us again uh as Frank had

1124
00:47:49,670 --> 00:47:47,640
mentioned is resolution so this is pre

1125
00:47:51,770 --> 00:47:49,680
there was a previous Spitzer image here

1126
00:47:54,170 --> 00:47:51,780
and then we were able to transition to

1127
00:47:57,230 --> 00:47:54,180
what James Webb brings up uh us now so

1128
00:47:59,510 --> 00:47:57,240
James Webb has a much larger mirror and

1129
00:48:02,030 --> 00:47:59,520
so we're going to be able to pick up

1130
00:48:03,770 --> 00:48:02,040
much finer resolution imaging and

1131
00:48:06,650 --> 00:48:03,780
additionally since it is a larger mirror

1132
00:48:10,069 --> 00:48:06,660
we're also collecting more photons per

1133
00:48:11,870 --> 00:48:10,079
observation uh hour so we're going to be

1134
00:48:13,490 --> 00:48:11,880
able to collect more photons and then

1135
00:48:15,470 --> 00:48:13,500
have a sharper image of where those

1136
00:48:17,329 --> 00:48:15,480
photons are coming from thanks to the

1137
00:48:18,829 --> 00:48:17,339
James Webb observations

1138
00:48:24,410 --> 00:48:18,839

so

1139
00:48:30,890 --> 00:48:27,410
um what does that mean for me like what

1140
00:48:33,290 --> 00:48:30,900
do I do with James Webb with AGN like

1141
00:48:35,390 --> 00:48:33,300
how are am I involved in all of this

1142
00:48:39,109 --> 00:48:35,400
well so what I'm trying to understand

1143
00:48:40,550 --> 00:48:39,119
then is how the ionize gas that we're

1144
00:48:42,470 --> 00:48:40,560
looking at in all of these previous

1145
00:48:43,790 --> 00:48:42,480
observations

1146
00:48:45,650 --> 00:48:43,800
um right now I'm really interested in

1147
00:48:49,730 --> 00:48:45,660
how they're aligned with the radio

1148
00:48:51,349 --> 00:48:49,740
emission so radio is still light it's at

1149
00:48:53,690 --> 00:48:51,359
the far end of the electromagnetic

1150
00:48:56,270 --> 00:48:53,700
spectrum and we're seeing that the radio

1151
00:48:59,510 --> 00:48:56,280
structure which is the blue contour maps

1152
00:49:01,250 --> 00:48:59,520
uh in this slide is related to the fried

1153
00:49:03,650 --> 00:49:01,260
ionized gas that I was talking about

1154
00:49:06,890 --> 00:49:03,660
earlier which is the Green in this slide

1155
00:49:09,109 --> 00:49:06,900
and so often in AGN we see them aligned

1156
00:49:10,849 --> 00:49:09,119
but there are also these really

1157
00:49:13,670 --> 00:49:10,859
beautiful

1158
00:49:15,950 --> 00:49:13,680
um radio loud galaxies that have these

1159
00:49:18,410 --> 00:49:15,960
magnificent Jets so you can see that the

1160
00:49:21,470 --> 00:49:18,420
Galaxy is kind of perpendicular to this

1161
00:49:24,890 --> 00:49:21,480
very beam-like structure here and so

1162
00:49:27,470 --> 00:49:24,900
folks are seeing these radio gets and

1163
00:49:29,809 --> 00:49:27,480

then they see the radio structures in

1164
00:49:31,730 --> 00:49:29,819
these other AGN these other

1165
00:49:34,730 --> 00:49:31,740
um these less magnificent ones and they

1166
00:49:38,510 --> 00:49:34,740
say are these processes related

1167
00:49:40,190 --> 00:49:38,520
um and so what I am not so sure of is

1168
00:49:41,990 --> 00:49:40,200
whether they are related I think that

1169
00:49:44,510 --> 00:49:42,000
they might be due to different processes

1170
00:49:46,790 --> 00:49:44,520
so when we're looking at

1171
00:49:49,130 --> 00:49:46,800
um active galaxies that aren't that

1172
00:49:52,250 --> 00:49:49,140
don't have those magnificent plumes of

1173
00:49:54,230 --> 00:49:52,260
radio we often see that the radio

1174
00:49:56,809 --> 00:49:54,240
structure is aligned with the ionized

1175
00:49:59,329 --> 00:49:56,819
gas and here's a train of many different

1176
00:50:01,550 --> 00:49:59,339
papers that compare uh the maps are

1177
00:50:04,430 --> 00:50:01,560
often the ionized gas and the Contours

1178
00:50:07,550 --> 00:50:04,440
are the radio data and we always see the

1179
00:50:10,550 --> 00:50:07,560
radio data that is intertwined with the

1180
00:50:13,970 --> 00:50:10,560
ionized gas here and so what's that

1181
00:50:17,030 --> 00:50:13,980
suggesting to me is that the radio

1182
00:50:19,550 --> 00:50:17,040
structure is always in the plane of the

1183
00:50:21,230 --> 00:50:19,560
host Galaxy because that's where the

1184
00:50:23,630 --> 00:50:21,240
ionized gas is coming from it's being

1185
00:50:27,230 --> 00:50:23,640
its molecular gas lanes that are being

1186
00:50:29,450 --> 00:50:27,240
lit up by that flashlight of Doom and so

1187
00:50:31,490 --> 00:50:29,460
if the radio structure is along where

1188
00:50:33,410 --> 00:50:31,500

that flashlight of Doom structure is

1189
00:50:34,790 --> 00:50:33,420
that means that the radio always has to

1190
00:50:37,790 --> 00:50:34,800
be in the plane of the Galaxy which

1191
00:50:39,290 --> 00:50:37,800
would be weird if it was just a jet a

1192
00:50:41,690 --> 00:50:39,300
plume that could be any individual

1193
00:50:44,329 --> 00:50:41,700
inclination so what I'm testing right

1194
00:50:47,150 --> 00:50:44,339
now is that the radio structure that

1195
00:50:49,309 --> 00:50:47,160
we're seeing might actually be due to

1196
00:50:51,770 --> 00:50:49,319
the winds that are launched from that

1197
00:50:53,690 --> 00:50:51,780
active galaxy in the center slamming

1198
00:50:55,790 --> 00:50:53,700
into dense medium that can no longer

1199
00:50:57,410 --> 00:50:55,800
drive out away from the center of the

1200
00:50:59,030 --> 00:50:57,420
Galaxy and when you have these high

1201
00:51:01,430 --> 00:50:59,040
velocity winds that we talked about

1202
00:51:03,410 --> 00:51:01,440
earlier traveling hundreds to thousands

1203
00:51:05,210 --> 00:51:03,420
of kilometers per second they slam into

1204
00:51:08,210 --> 00:51:05,220
this dense molecular gas that it can't

1205
00:51:10,069 --> 00:51:08,220
drive anymore and it creates a shock

1206
00:51:12,349 --> 00:51:10,079
that's very similar to what you'd see in

1207
00:51:14,150 --> 00:51:12,359
like a supernova Remnant and so what

1208
00:51:17,150 --> 00:51:14,160
you're seeing then are just the Galaxy

1209
00:51:19,309 --> 00:51:17,160
scale Supernova remnants that are

1210
00:51:21,230 --> 00:51:19,319
producing this radio structure that

1211
00:51:23,990 --> 00:51:21,240
looks like those plumes that we see in

1212
00:51:25,970 --> 00:51:24,000
some of these other AGM so that kind of

1213
00:51:27,650 --> 00:51:25,980

brings us back to the beginning then

1214
00:51:29,630 --> 00:51:27,660
um so that I had this picture of a

1215
00:51:32,569 --> 00:51:29,640
Galaxy at the beginning of the talk and

1216
00:51:35,270 --> 00:51:32,579
what's going on uh with that is that we

1217
00:51:38,210 --> 00:51:35,280
are planning to observe this target uh

1218
00:51:40,250 --> 00:51:38,220
with James Webb uh later this month I'm

1219
00:51:43,130 --> 00:51:40,260
super excited um so this is a very

1220
00:51:45,950 --> 00:51:43,140
nearby Galaxy that has these radio

1221
00:51:48,710 --> 00:51:45,960
plumes going on here and I want to test

1222
00:51:50,630 --> 00:51:48,720
whether the radio structure these blue

1223
00:51:53,150 --> 00:51:50,640
this blue s-shaped structure that you're

1224
00:51:55,730 --> 00:51:53,160
seeing here lies along where that

1225
00:51:57,349 --> 00:51:55,740
glowing dust is and the Imaging that we

1226
00:52:00,049 --> 00:51:57,359
taught we showed earlier so we're going

1227
00:52:01,549 --> 00:52:00,059
to compare the blue structure here with

1228
00:52:04,849 --> 00:52:01,559
the emission that we're seeing from the

1229
00:52:08,089 --> 00:52:04,859
James Webb infrared cameras to show that

1230
00:52:10,010 --> 00:52:08,099
again the radio structure is in the

1231
00:52:12,349 --> 00:52:10,020
plane of the host disk because what's

1232
00:52:14,569 --> 00:52:12,359
probably happening is that the winds are

1233
00:52:17,569 --> 00:52:14,579
launching outward shocking the material

1234
00:52:20,630 --> 00:52:17,579
in the host Galaxy and producing this

1235
00:52:23,870 --> 00:52:20,640
what looks like a plume or a jet

1236
00:52:25,630 --> 00:52:23,880
um but it's actually just a giant uh

1237
00:52:28,910 --> 00:52:25,640
Galaxy size

1238
00:52:33,049 --> 00:52:28,920

supernova-esque remnant

1239
00:52:36,290 --> 00:52:33,059
so um to wrap up uh Asian are dangerous

1240
00:52:38,510 --> 00:52:36,300
are we in danger uh and I would just

1241
00:52:41,870 --> 00:52:38,520
like to dissuade you from being nervous

1242
00:52:44,809 --> 00:52:41,880
because uh we've seen that the Milky Way

1243
00:52:48,710 --> 00:52:44,819
had an active period about 2.6 million

1244
00:52:50,569 --> 00:52:48,720
years ago and that uh the evidence of

1245
00:52:52,609 --> 00:52:50,579
this active period is highlighted by

1246
00:52:55,250 --> 00:52:52,619
these high energy bubbles that are

1247
00:52:56,930 --> 00:52:55,260
driven perpendicular from the host

1248
00:52:58,370 --> 00:52:56,940
Galaxy

1249
00:53:01,309 --> 00:52:58,380
um that is that line that we looked at

1250
00:53:04,010 --> 00:53:01,319
earlier so here's kind of an animation

1251
00:53:06,410 --> 00:53:04,020
of what's Happening Here Right so here

1252
00:53:08,270 --> 00:53:06,420
again the the radiation field that's

1253
00:53:09,829 --> 00:53:08,280
coming from the active Galactic nucleus

1254
00:53:12,290 --> 00:53:09,839
in the center is pointed out of the

1255
00:53:14,030 --> 00:53:12,300
plane of the Galaxy and we're probably

1256
00:53:16,549 --> 00:53:14,040
not going to have to deal with any of

1257
00:53:18,890 --> 00:53:16,559
the massive amounts of radiation that

1258
00:53:20,290 --> 00:53:18,900
would be pouring out of it as is pointed

1259
00:53:24,230 --> 00:53:20,300
out of the plane so we're probably

1260
00:53:26,030 --> 00:53:24,240
relatively safe so uh with that I thank

1261
00:53:27,530 --> 00:53:26,040
you so much for your time and I'd love

1262
00:53:30,589 --> 00:53:27,540
to answer any questions that you have

1263
00:53:36,710 --> 00:53:33,410

all right thank you very much Travis

1264
00:53:39,349 --> 00:53:36,720
that was a I don't know probably the

1265
00:53:41,150 --> 00:53:39,359
most active talk that we've ever seen I

1266
00:53:43,370 --> 00:53:41,160
guess on active galaxies is going to do

1267
00:53:45,470 --> 00:53:43,380
but you use more Transitions and

1268
00:53:48,109 --> 00:53:45,480
animations and such than anybody else to

1269
00:53:50,329 --> 00:53:48,119
do so big Applause for that that was

1270
00:53:53,809 --> 00:53:50,339
extremely well prepared

1271
00:53:57,470 --> 00:53:53,819
so I get to ask the first question

1272
00:53:59,270 --> 00:53:57,480
um and my first question for you is um

1273
00:54:01,849 --> 00:53:59,280
let's let's get into this

1274
00:54:04,970 --> 00:54:01,859
active galaxies as to how long they

1275
00:54:07,069 --> 00:54:04,980
remain active okay and and so like it's

1276
00:54:09,290 --> 00:54:07,079
just sort of two questions in one is

1277
00:54:11,750 --> 00:54:09,300
that that um you know you say that the

1278
00:54:15,230 --> 00:54:11,760
Milky Way is not active now but it used

1279
00:54:19,010 --> 00:54:15,240
to be active Okay so at any one time

1280
00:54:21,109 --> 00:54:19,020
what percentage of galaxies are active

1281
00:54:23,569 --> 00:54:21,119
um and that's sort of related to how

1282
00:54:25,670 --> 00:54:23,579
long does a Galaxy remain active once it

1283
00:54:27,710 --> 00:54:25,680
becomes active uh what what what what

1284
00:54:31,010 --> 00:54:27,720
percentage of its lifetime is it an

1285
00:54:33,349 --> 00:54:31,020
active Galaxy right so galaxies are

1286
00:54:35,450 --> 00:54:33,359
active and it's not because they don't

1287
00:54:37,490 --> 00:54:35,460
just turn on necessarily there has to be

1288
00:54:39,170 --> 00:54:37,500

a reason that the material is funneling

1289
00:54:40,849 --> 00:54:39,180
into that supermassive black hole like

1290
00:54:44,390 --> 00:54:40,859
that star that was traveling toward the

1291
00:54:46,970 --> 00:54:44,400
black hole it wasn't just on a happy

1292
00:54:49,309 --> 00:54:46,980
path it was probably flung there from a

1293
00:54:51,589 --> 00:54:49,319
binary system or some reason to be flung

1294
00:54:54,470 --> 00:54:51,599
out of its orbit toward that black hole

1295
00:54:57,170 --> 00:54:54,480
so um galaxies often under undergo

1296
00:54:58,670 --> 00:54:57,180
mergers or there's maybe some sort of uh

1297
00:55:01,609 --> 00:54:58,680
stream of gas that's coming from a

1298
00:55:03,829 --> 00:55:01,619
neighboring Galaxy see that falls in to

1299
00:55:05,809 --> 00:55:03,839
activate the supermassive black hole at

1300
00:55:06,770 --> 00:55:05,819
the center of the Galaxy and so we see

1301
00:55:09,349 --> 00:55:06,780
that

1302
00:55:11,150 --> 00:55:09,359
um often it's only a few percent of all

1303
00:55:14,390 --> 00:55:11,160
of the millions of galaxies that we know

1304
00:55:17,030 --> 00:55:14,400
of are active at any given time and

1305
00:55:21,829 --> 00:55:17,040
um we're not really sure how long an

1306
00:55:23,750 --> 00:55:21,839
active period in an AGN lasts I I don't

1307
00:55:27,230 --> 00:55:23,760
know if I've ever seen one ever turn on

1308
00:55:29,750 --> 00:55:27,240
or turn off necessarily but they should

1309
00:55:31,490 --> 00:55:29,760
last uh we we think that they last like

1310
00:55:33,049 --> 00:55:31,500
a couple hundred thousand years at a

1311
00:55:35,690 --> 00:55:33,059
time

1312
00:55:39,250 --> 00:55:35,700
um so but yes I've never seen one turn

1313
00:55:44,150 --> 00:55:41,809

so nobody just sort of flips the switch

1314
00:55:45,890 --> 00:55:44,160
and says okay you're now active and then

1315
00:55:47,510 --> 00:55:45,900
all right that's right hey I need I need

1316
00:55:50,230 --> 00:55:47,520
some it's some quiet over here stop

1317
00:55:52,370 --> 00:55:50,240
being active yeah we're done yeah

1318
00:55:55,250 --> 00:55:52,380
I wish you could do that with your kids

1319
00:56:01,549 --> 00:55:58,010
so uh Grant justice has been monitoring

1320
00:56:03,890 --> 00:56:01,559
the chat we've had in ex excellent chat

1321
00:56:06,530 --> 00:56:03,900
here uh thing Grant is going to join us

1322
00:56:08,510 --> 00:56:06,540
and pull some questions from that chat

1323
00:56:10,250 --> 00:56:08,520
for you what have you got for us tonight

1324
00:56:12,470 --> 00:56:10,260
Grant

1325
00:56:14,329 --> 00:56:12,480
um first before I begin the questions I

1326
00:56:16,010 --> 00:56:14,339
have to say flashlight of Doom is the

1327
00:56:17,630 --> 00:56:16,020
best descriptor I've ever heard in a

1328
00:56:21,770 --> 00:56:17,640
public lecture series

1329
00:56:24,230 --> 00:56:21,780
so it's not a guitar a plus a plus

1330
00:56:25,730 --> 00:56:24,240
all right um so first question starting

1331
00:56:28,370 --> 00:56:25,740
off um

1332
00:56:31,250 --> 00:56:28,380
do supermassive black holes behave

1333
00:56:33,349 --> 00:56:31,260
differently from quote unquote regular

1334
00:56:35,329 --> 00:56:33,359
black holes because they were formed

1335
00:56:38,569 --> 00:56:35,339
through a different process

1336
00:56:40,910 --> 00:56:38,579
well uh we don't know how supermassive

1337
00:56:43,849 --> 00:56:40,920
black holes form so

1338
00:56:45,049 --> 00:56:43,859

um it would be uh a good question or a

1339
00:56:46,370 --> 00:56:45,059
good answer to figure out first of all

1340
00:56:49,490 --> 00:56:46,380
but

1341
00:56:53,569 --> 00:56:49,500
um no uh any black hole essentially has

1342
00:56:55,730 --> 00:56:53,579
a mast a mass and a spin how much it's

1343
00:56:57,290 --> 00:56:55,740
spinning and I think that no matter the

1344
00:57:00,109 --> 00:56:57,300
mass of that black hole those are the

1345
00:57:02,030 --> 00:57:00,119
two parameters that we really only we

1346
00:57:04,190 --> 00:57:02,040
know about the black hole so I mean

1347
00:57:07,670 --> 00:57:04,200
there's been a lot of work to try to

1348
00:57:10,010 --> 00:57:07,680
understand so you see like the Stellar

1349
00:57:12,650 --> 00:57:10,020
Mass black holes are often eating

1350
00:57:14,870 --> 00:57:12,660
material from a binary star system so

1351
00:57:16,849 --> 00:57:14,880
it's a black hole uh and a star

1352
00:57:18,410 --> 00:57:16,859
companion and so it's eating the

1353
00:57:20,329 --> 00:57:18,420
material off of that Stellar companion

1354
00:57:22,309 --> 00:57:20,339
and creating an accretion disk and

1355
00:57:24,470 --> 00:57:22,319
there's material flying off of it and we

1356
00:57:27,109 --> 00:57:24,480
try we want to be able to relate that to

1357
00:57:29,569 --> 00:57:27,119
what we see in AGN but it just hasn't

1358
00:57:30,849 --> 00:57:29,579
clicked so far so it's just the

1359
00:57:33,170 --> 00:57:30,859
environment is just a little different

1360
00:57:35,930 --> 00:57:33,180
between the two

1361
00:57:38,030 --> 00:57:35,940
um that we can't really compare the

1362
00:57:40,970 --> 00:57:38,040
science that's going on between them

1363
00:57:41,990 --> 00:57:40,980

but they are relatively the same object

1364
00:57:44,150 --> 00:57:42,000
right

1365
00:57:46,010 --> 00:57:44,160
and uh if I remember my graduate school

1366
00:57:48,650 --> 00:57:46,020
work there were three parameters that

1367
00:57:51,530 --> 00:57:48,660
black hole could have a mass Spin and

1368
00:57:53,750 --> 00:57:51,540
charge but they're so they're so large

1369
00:57:55,970 --> 00:57:53,760
that they generally would never ever get

1370
00:57:58,549 --> 00:57:55,980
an A positive or electric or negative

1371
00:58:01,870 --> 00:57:58,559
electric charge it would all balance out

1372
00:58:07,130 --> 00:58:04,549
gotcha um so at the beginning you

1373
00:58:09,950 --> 00:58:07,140
mentioned that black holes are very much

1374
00:58:13,910 --> 00:58:09,960
not as you would expect from the

1375
00:58:18,230 --> 00:58:13,920
Hollywood depiction per se but what does

1376
00:58:20,329 --> 00:58:18,240
happen to time near or in per se a black

1377
00:58:21,770 --> 00:58:20,339
hole I mean you knew it was coming you

1378
00:58:23,030 --> 00:58:21,780
knew come on Travis you know that

1379
00:58:27,910 --> 00:58:23,040
questions like this are going to be are

1380
00:58:31,849 --> 00:58:27,920
out there yeah I mean I don't

1381
00:58:34,790 --> 00:58:31,859
I don't know probably like I I so fair

1382
00:58:37,069 --> 00:58:34,800
answer though yeah so like but I mean

1383
00:58:40,309 --> 00:58:37,079
it's just because of my inexperience

1384
00:58:42,230 --> 00:58:40,319
with it because I deal ideally like I go

1385
00:58:45,170 --> 00:58:42,240
to these conferences uh looking at

1386
00:58:47,089 --> 00:58:45,180
active Galactic nuclei and there's uh a

1387
00:58:48,650 --> 00:58:47,099
whole spectrum of people that start from

1388
00:58:50,690 --> 00:58:48,660

the very center where there's the black

1389
00:58:52,789 --> 00:58:50,700
hole and the accretion disk and then

1390
00:58:57,049 --> 00:58:52,799
there's like the around that is a big

1391
00:58:59,270 --> 00:58:57,059
Dusty Taurus and then past that is like

1392
00:59:01,190 --> 00:58:59,280
maybe like the high energy people and

1393
00:59:02,809 --> 00:59:01,200
then I'm way out here that's looking at

1394
00:59:05,750 --> 00:59:02,819
like the winds interacting with the host

1395
00:59:08,030 --> 00:59:05,760
Galaxy and what that's doing and so even

1396
00:59:10,849 --> 00:59:08,040
though we're all the same like

1397
00:59:12,650 --> 00:59:10,859
astronomers I don't know what's going on

1398
00:59:14,870 --> 00:59:12,660
like I don't have the answers for what's

1399
00:59:17,150 --> 00:59:14,880
going on down there because I just I'm

1400
00:59:19,130 --> 00:59:17,160
not ever talking about it enough so I I

1401
00:59:20,690 --> 00:59:19,140
don't have the the brilliant answer for

1402
00:59:22,849 --> 00:59:20,700
that

1403
00:59:24,230 --> 00:59:22,859
there it's a highly specialized field of

1404
00:59:26,510 --> 00:59:24,240
study

1405
00:59:27,470 --> 00:59:26,520
there are many different facets so all

1406
00:59:29,870 --> 00:59:27,480
right

1407
00:59:31,910 --> 00:59:29,880
um go home and cry that I'm not a

1408
00:59:34,309 --> 00:59:31,920
customer I should be there are no

1409
00:59:36,230 --> 00:59:34,319
they're they're folks who specialize in

1410
00:59:38,510 --> 00:59:36,240
trying to tell the public what a black

1411
00:59:40,490 --> 00:59:38,520
hole is like you know uh the one thing I

1412
00:59:43,730 --> 00:59:40,500
remember from uh all these discussions

1413
00:59:45,890 --> 00:59:43,740

is supermassive black holes is that the

1414
00:59:48,230 --> 00:59:45,900
um the sword shield radius is so large

1415
00:59:50,210 --> 00:59:48,240
it's solar system size that's that your

1416
00:59:51,890 --> 00:59:50,220
spaceship passing through this where

1417
00:59:54,589 --> 00:59:51,900
it's passing in through the Event

1418
00:59:57,109 --> 00:59:54,599
Horizon wouldn't really be as you know

1419
00:59:59,030 --> 00:59:57,119
stretched out as it would be you know um

1420
01:00:03,049 --> 00:59:59,040
working with a stellar Mass black hole

1421
01:00:04,250 --> 01:00:03,059
the uh that the field is is as much much

1422
01:00:06,530 --> 01:00:04,260
more spread

1423
01:00:08,930 --> 01:00:06,540
I don't know it's it's still intense but

1424
01:00:11,510 --> 01:00:08,940
it's it's the the the tidal forces

1425
01:00:13,130 --> 01:00:11,520
aren't as strong right yeah

1426
01:00:14,030 --> 01:00:13,140
that's all I remember

1427
01:00:16,730 --> 01:00:14,040
okay

1428
01:00:19,250 --> 01:00:16,740
gotcha I would say um to the user who

1429
01:00:21,530 --> 01:00:19,260
asked I think your name was you too

1430
01:00:23,510 --> 01:00:21,540
um just go ahead and check some of our

1431
01:00:24,950 --> 01:00:23,520
other public lectures we've had quite a

1432
01:00:26,990 --> 01:00:24,960
few on this and I'm from the more

1433
01:00:30,770 --> 01:00:27,000
knowledgeable astronomers go find them

1434
01:00:33,470 --> 01:00:30,780
and no someone who specializes in that

1435
01:00:35,990 --> 01:00:33,480
particular section of black hole study

1436
01:00:38,109 --> 01:00:36,000
hahaha don't apologize for having a

1437
01:00:39,890 --> 01:00:38,119
specialty it's a good thing

1438
01:00:42,650 --> 01:00:39,900

all right

1439
01:00:44,690 --> 01:00:42,660
um have we observed any agns that are

1440
01:00:47,089 --> 01:00:44,700
ending an active period and becoming

1441
01:00:49,789 --> 01:00:47,099
inactive

1442
01:00:51,049 --> 01:00:49,799
okay so yeah you sort of caught that oh

1443
01:00:52,730 --> 01:00:51,059
we kind of covered that a little bit

1444
01:00:56,390 --> 01:00:52,740
more in the beginning that's so yes

1445
01:01:01,849 --> 01:00:59,030
like these light Echoes right so the

1446
01:01:03,530 --> 01:01:01,859
radiation is traveling at the speed of

1447
01:01:06,289 --> 01:01:03,540
light it can't go any faster than that

1448
01:01:08,630 --> 01:01:06,299
so you can see uh some Galaxies have

1449
01:01:11,030 --> 01:01:08,640
these radiation these ionization the

1450
01:01:13,130 --> 01:01:11,040
flashlight is still on at Great

1451
01:01:15,950 --> 01:01:13,140
distances but the AGN has turned off

1452
01:01:18,230 --> 01:01:15,960
since then and so at smaller distances

1453
01:01:20,630 --> 01:01:18,240
the flashlight is off right so you see

1454
01:01:22,430 --> 01:01:20,640
we call them four Works

1455
01:01:23,990 --> 01:01:22,440
um so the radiation has run out is

1456
01:01:26,150 --> 01:01:24,000
running through the host Galaxy or

1457
01:01:27,950 --> 01:01:26,160
whatever it's running into but the AGN

1458
01:01:30,890 --> 01:01:27,960
is now off so there's like it's just

1459
01:01:32,270 --> 01:01:30,900
this cloud of ionized gas by itself

1460
01:01:35,030 --> 01:01:32,280
that's

1461
01:01:37,430 --> 01:01:35,040
um because the AGN has turned off

1462
01:01:39,710 --> 01:01:37,440
okay so that bring that begs the

1463
01:01:41,870 --> 01:01:39,720

question is how do we know that the I

1464
01:01:44,030 --> 01:01:41,880
mean we we see the the bubbles in the

1465
01:01:46,250 --> 01:01:44,040
Milky Way how do we know it was 2.6

1466
01:01:48,250 --> 01:01:46,260
million years ago

1467
01:01:51,829 --> 01:01:48,260
um for the the yeah

1468
01:01:54,710 --> 01:01:51,839
I'm not sure I I was touching base with

1469
01:01:56,510 --> 01:01:54,720
some folks about that

1470
01:01:58,910 --> 01:01:56,520
um but I think it might just be the

1471
01:02:00,890 --> 01:01:58,920
energetics and the required velocity

1472
01:02:03,589 --> 01:02:00,900
that things are traveling um to create

1473
01:02:04,910 --> 01:02:03,599
to puff up that bubble at the velocities

1474
01:02:07,970 --> 01:02:04,920
that they're traveling now you would

1475
01:02:12,170 --> 01:02:07,980
require require you to walk back 2.6

1476
01:02:17,870 --> 01:02:15,530
valid okay

1477
01:02:21,170 --> 01:02:17,880
um so

1478
01:02:23,270 --> 01:02:21,180
you had mentioned radio structures uh at

1479
01:02:25,970 --> 01:02:23,280
the very end of your talk what

1480
01:02:28,549 --> 01:02:25,980
frequencies Do You observe those at and

1481
01:02:37,250 --> 01:02:28,559
what about radio emissions from Galactic

1482
01:02:40,930 --> 01:02:39,370
I'd have to go

1483
01:02:45,109 --> 01:02:40,940
26.63.

1484
01:02:50,630 --> 01:02:47,510
but I mean is this really to things like

1485
01:02:53,450 --> 01:02:50,640
Hercules a or you you mentioned physical

1486
01:02:57,950 --> 01:02:53,460
Galaxy okay got it so

1487
01:03:02,450 --> 01:02:59,750
I mean that's the image of Centaurus a

1488
01:03:05,569 --> 01:03:02,460

you have these radio Jets and radio Jets

1489
01:03:10,190 --> 01:03:05,579
come from are prominent in what are

1490
01:03:12,170 --> 01:03:10,200
called radio loud AGN so while AGN only

1491
01:03:15,170 --> 01:03:12,180
are a few percentage of all of the

1492
01:03:17,569 --> 01:03:15,180
galaxies in the universe radio loud AGN

1493
01:03:19,910 --> 01:03:17,579
are only a few percentage of all of the

1494
01:03:21,230 --> 01:03:19,920
AGN in the universe and so you have

1495
01:03:24,049 --> 01:03:21,240
these environments where you're

1496
01:03:26,270 --> 01:03:24,059
producing these very long plumes these

1497
01:03:29,030 --> 01:03:26,280
jets these radio Jets have relativistic

1498
01:03:30,890 --> 01:03:29,040
plasma this stuff is traveling almost

1499
01:03:33,890 --> 01:03:30,900
the suite of light and you can measure

1500
01:03:36,049 --> 01:03:33,900
like the Vlog traveling at these

1501
01:03:38,870 --> 01:03:36,059
relativistic speeds when we observe them

1502
01:03:42,230 --> 01:03:38,880
over time and so the point that I was

1503
01:03:44,210 --> 01:03:42,240
trying to make then is that uh in a lot

1504
01:03:46,670 --> 01:03:44,220
of these radio quiet AGN which is the

1505
01:03:50,750 --> 01:03:46,680
majority of AGM that we study we also

1506
01:03:52,910 --> 01:03:50,760
see radio structures and so uh folks see

1507
01:03:55,789 --> 01:03:52,920
these elongated radio structures and

1508
01:03:57,829 --> 01:03:55,799
they say boom that is also a jet because

1509
01:03:59,930 --> 01:03:57,839
I know what a jet looks like and it

1510
01:04:03,770 --> 01:03:59,940
looks like that so

1511
01:04:06,950 --> 01:04:03,780
um but what I'm trying to uh

1512
01:04:09,109 --> 01:04:06,960
show or confirm or find evidence to deny

1513
01:04:10,370 --> 01:04:09,119

I mean this we're just testing it out is

1514
01:04:12,829 --> 01:04:10,380
to

1515
01:04:15,530 --> 01:04:12,839
find out if that radio structure is not

1516
01:04:17,450 --> 01:04:15,540
a jet it's actually a shock process

1517
01:04:19,250 --> 01:04:17,460
similar to what you're seeing in the

1518
01:04:21,049 --> 01:04:19,260
Supernova remnants okay so you have the

1519
01:04:22,730 --> 01:04:21,059
winds that are running out from the

1520
01:04:25,430 --> 01:04:22,740
center of the Galaxy they're running

1521
01:04:27,650 --> 01:04:25,440
into host disk material shocking it and

1522
01:04:30,049 --> 01:04:27,660
producing that radio structure as kind

1523
01:04:33,890 --> 01:04:30,059
of like a splash along the edge of that

1524
01:04:36,589 --> 01:04:33,900
dense molecular gasoline so the a

1525
01:04:38,809 --> 01:04:36,599
general hypothesis or test would be if

1526
01:04:42,530 --> 01:04:38,819
these aren't due to winds running into

1527
01:04:45,470 --> 01:04:42,540
material there should be these jets in

1528
01:04:47,930 --> 01:04:45,480
these radio quiet AGN that are traveling

1529
01:04:49,970 --> 01:04:47,940
at this at angles that are not aligned

1530
01:04:52,910 --> 01:04:49,980
with the host disk but every single

1531
01:04:54,910 --> 01:04:52,920
Galaxy that I've looked at that um that

1532
01:04:57,770 --> 01:04:54,920
we've I showed in that train of images

1533
01:05:00,829 --> 01:04:57,780
always shows that the radio structure is

1534
01:05:02,270 --> 01:05:00,839
aligned with the ionized fried gas which

1535
01:05:04,309 --> 01:05:02,280
means that it's always in the plane of

1536
01:05:07,670 --> 01:05:04,319
the Galaxy so

1537
01:05:09,650 --> 01:05:07,680
um NGC 2663 is an elliptical galaxy I'm

1538
01:05:11,329 --> 01:05:09,660

presuming it's radio loud and it doesn't

1539
01:05:13,849 --> 01:05:11,339
have any sort of has to be running into

1540
01:05:16,549 --> 01:05:13,859
and it probably has a pencil beam radio

1541
01:05:18,770 --> 01:05:16,559
Jet and that is not the same then as

1542
01:05:21,289 --> 01:05:18,780
what we're seeing in a majority of these

1543
01:05:23,329 --> 01:05:21,299
AGN and so why is that important because

1544
01:05:25,130 --> 01:05:23,339
then we can start measuring the amount

1545
01:05:26,690 --> 01:05:25,140
the the distance at which positive

1546
01:05:29,990 --> 01:05:26,700
feedback where you're compressing that

1547
01:05:32,870 --> 01:05:30,000
gas the maximum amount of uh the maximum

1548
01:05:35,089 --> 01:05:32,880
radius at which positive feedback exists

1549
01:05:37,789 --> 01:05:35,099
and so this is just helping us

1550
01:05:40,670 --> 01:05:37,799
understand the overall picture of radio

1551
01:05:43,069 --> 01:05:40,680
agent feedback then by knowing that it's

1552
01:05:44,990 --> 01:05:43,079
not a jet invoking a jet but it actually

1553
01:05:46,730 --> 01:05:45,000
is a byproduct of the Winds interacting

1554
01:05:48,589 --> 01:05:46,740
with the host Galaxy

1555
01:05:50,030 --> 01:05:48,599
right and and we should make sure that

1556
01:05:52,309 --> 01:05:50,040
our audience understands that elliptical

1557
01:05:55,069 --> 01:05:52,319
galaxies generally have very little gas

1558
01:05:56,809 --> 01:05:55,079
and dust right in them so that it can't

1559
01:05:59,329 --> 01:05:56,819
run into stuff all right that doesn't

1560
01:06:01,010 --> 01:05:59,339
have it uh and so versus the spiral

1561
01:06:04,010 --> 01:06:01,020
galaxies which would be more what you're

1562
01:06:05,690 --> 01:06:04,020
studying that's right so yes most of

1563
01:06:08,270 --> 01:06:05,700

these radio loud galaxies are the

1564
01:06:10,309 --> 01:06:08,280
elliptical galaxies which are red and

1565
01:06:11,870 --> 01:06:10,319
dead there's not a lot of gas that

1566
01:06:14,450 --> 01:06:11,880
what's behind me here is a spiral galaxy

1567
01:06:16,609 --> 01:06:14,460
so you got lots of blue stars happening

1568
01:06:19,789 --> 01:06:16,619
here a lot of young star formation a lot

1569
01:06:22,370 --> 01:06:19,799
of gas to form Stars ellipticals have uh

1570
01:06:24,170 --> 01:06:22,380
have little to no gas in them and so all

1571
01:06:26,270 --> 01:06:24,180
the stars are just the smoldering Embers

1572
01:06:27,710 --> 01:06:26,280
of the low mass stars that still exist

1573
01:06:31,130 --> 01:06:27,720
there

1574
01:06:34,390 --> 01:06:31,140
all right uh Grant what else have we got

1575
01:06:38,569 --> 01:06:34,400
from the chat here tonight

1576
01:06:40,609 --> 01:06:38,579
variation here yeah I have uh I've seen

1577
01:06:43,910 --> 01:06:40,619
a couple of variations of the same

1578
01:06:46,190 --> 01:06:43,920
question which is what causes the Jets

1579
01:06:48,650 --> 01:06:46,200
to shoot in their particular directions

1580
01:06:51,349 --> 01:06:48,660
rather than just anywhere and everywhere

1581
01:06:53,990 --> 01:06:51,359
great yeah so what we think is happening

1582
01:06:56,930 --> 01:06:54,000
when you're creating a radio jet is that

1583
01:07:00,529 --> 01:06:56,940
so we have seen the accretion disk let's

1584
01:07:02,210 --> 01:07:00,539
actually kind of go back can I play my

1585
01:07:04,130 --> 01:07:02,220
slides a little bit again

1586
01:07:11,750 --> 01:07:04,140
yeah absolutely no problem uh start your

1587
01:07:16,069 --> 01:07:13,970
um so here's this animation that's

1588
01:07:19,069 --> 01:07:16,079

showing the material is being stripped

1589
01:07:22,490 --> 01:07:19,079
from this star and is forming the

1590
01:07:24,890 --> 01:07:22,500
accretion disk around uh the black hole

1591
01:07:26,870 --> 01:07:24,900
in this animation and so

1592
01:07:29,029 --> 01:07:26,880
um our models predict and what you can

1593
01:07:32,450 --> 01:07:29,039
see here perpendicular to that accretion

1594
01:07:35,210 --> 01:07:32,460
disk is the radio jet in this cartoon so

1595
01:07:37,549 --> 01:07:35,220
the jet that is being emitted by this

1596
01:07:41,150 --> 01:07:37,559
black hole in this system is going to be

1597
01:07:43,690 --> 01:07:41,160
perpendicular to that accretion disk so

1598
01:07:49,250 --> 01:07:43,700
if we say that the radio jet is related

1599
01:07:51,950 --> 01:07:49,260
to the uh orientation of the black hole

1600
01:07:53,750 --> 01:07:51,960
and the accretion disk if that means it

1601
01:07:55,250 --> 01:07:53,760
should it's there is no relationship

1602
01:07:57,170 --> 01:07:55,260
between the orientation of the

1603
01:08:00,289 --> 01:07:57,180
supermassive black hole and its

1604
01:08:03,049 --> 01:08:00,299
accretion disk with the greater uh

1605
01:08:06,950 --> 01:08:03,059
Galaxy all right so if the Galaxy is in

1606
01:08:08,870 --> 01:08:06,960
the plane of this plane and the uh

1607
01:08:10,130 --> 01:08:08,880
accretion disc doesn't also have to be

1608
01:08:11,930 --> 01:08:10,140
in that plane it can be pointed like

1609
01:08:13,549 --> 01:08:11,940
this and then the winds are traveling in

1610
01:08:15,230 --> 01:08:13,559
this direction

1611
01:08:17,510 --> 01:08:15,240
um so it can be at any random

1612
01:08:19,849 --> 01:08:17,520
orientation versus that of the host that

1613
01:08:22,970 --> 01:08:19,859

it lives in however what we're finding

1614
01:08:25,789 --> 01:08:22,980
then is that the radio the radiojet is

1615
01:08:27,530 --> 01:08:25,799
always perpendicular or I mean I guess

1616
01:08:30,530 --> 01:08:27,540
it's always running into that plane of

1617
01:08:32,030 --> 01:08:30,540
the hostess material so if it was just a

1618
01:08:34,010 --> 01:08:32,040
jet it should be at some random

1619
01:08:36,410 --> 01:08:34,020
orientation shooting out at all any sort

1620
01:08:39,349 --> 01:08:36,420
of Direction but it's always pointed so

1621
01:08:41,030 --> 01:08:39,359
that the radio structure is along that

1622
01:08:42,590 --> 01:08:41,040
plane of that host galaxy of the

1623
01:08:44,450 --> 01:08:42,600
material that we're looking at in that

1624
01:08:46,789 --> 01:08:44,460
Galaxy

1625
01:08:49,070 --> 01:08:46,799
so you're saying that the radio emission

1626
01:08:50,870 --> 01:08:49,080
basically comes from the interaction of

1627
01:08:55,189 --> 01:08:50,880
the where the jet hits the material

1628
01:08:58,249 --> 01:08:55,199
that's in the disk so I'm saying that uh

1629
01:08:59,809 --> 01:08:58,259
yeah so if it was a jet it would be a

1630
01:09:01,789 --> 01:08:59,819
relativistic plasma that's traveling

1631
01:09:03,890 --> 01:09:01,799
perpendicular to the accretion disc

1632
01:09:06,650 --> 01:09:03,900
going off somewhere but what we're

1633
01:09:09,470 --> 01:09:06,660
seeing then is that the radiation from

1634
01:09:12,410 --> 01:09:09,480
the AGN is probably running outward into

1635
01:09:14,570 --> 01:09:12,420
that host plane material and smacking

1636
01:09:16,669 --> 01:09:14,580
into it and pressing it shocking it and

1637
01:09:20,150 --> 01:09:16,679
then the radio structure is formed right

1638
01:09:21,890 --> 01:09:20,160

there so your your um you create a bunch

1639
01:09:24,349 --> 01:09:21,900
of cosmic rays or a bunch of free

1640
01:09:27,289 --> 01:09:24,359
particles from the shock happening and

1641
01:09:30,110 --> 01:09:27,299
then the shock travels along uh magnetic

1642
01:09:32,689 --> 01:09:30,120
field lines in the gas the the cool gas

1643
01:09:34,550 --> 01:09:32,699
that's there and that produces what's

1644
01:09:36,890 --> 01:09:34,560
called uh synchrotron radiation so

1645
01:09:38,870 --> 01:09:36,900
that's a radio emission that is when

1646
01:09:41,209 --> 01:09:38,880
particles travel along magnetic field

1647
01:09:42,769 --> 01:09:41,219
lines and emit this radio structure so

1648
01:09:45,349 --> 01:09:42,779
that's the radio that you're seeing then

1649
01:09:48,110 --> 01:09:45,359
and since you're forming that Splash

1650
01:09:51,229 --> 01:09:48,120
along maybe like a spiral arm or some

1651
01:09:52,910 --> 01:09:51,239
sort of dust Lane that Splash looks like

1652
01:09:55,189 --> 01:09:52,920
it's called collimated it looks like

1653
01:09:57,709 --> 01:09:55,199
it's pollinated like the beam of a jet

1654
01:09:59,990 --> 01:09:57,719
so that's why people say oh that looks

1655
01:10:02,390 --> 01:10:00,000
like the jet that I'm used to looking at

1656
01:10:04,430 --> 01:10:02,400
um but what it is it's a red herring in

1657
01:10:06,410 --> 01:10:04,440
that sense is that it's it's not

1658
01:10:07,790 --> 01:10:06,420
actually being collimated

1659
01:10:09,709 --> 01:10:07,800
all right

1660
01:10:11,450 --> 01:10:09,719
so I mean that that's an interesting

1661
01:10:13,490 --> 01:10:11,460
point of view is that the interesting

1662
01:10:16,310 --> 01:10:13,500
point to make that the radio emission

1663
01:10:18,470 --> 01:10:16,320

happens where the energy is gets

1664
01:10:20,209 --> 01:10:18,480
deposited into the material that it runs

1665
01:10:22,250 --> 01:10:20,219
into right

1666
01:10:24,709 --> 01:10:22,260
um I remember the same sort of thing is

1667
01:10:25,910 --> 01:10:24,719
is true for some radio loud stuff in

1668
01:10:29,209 --> 01:10:25,920
terms of you getting the synchrotron

1669
01:10:32,209 --> 01:10:29,219
radiation wherever it slows down uh

1670
01:10:34,370 --> 01:10:32,219
which is on in those cases well outside

1671
01:10:36,709 --> 01:10:34,380
the the visible extent of the Galaxy

1672
01:10:39,709 --> 01:10:36,719
which is right yeah so you can't trace

1673
01:10:42,530 --> 01:10:39,719
like a molecular gasoline of the host

1674
01:10:44,689 --> 01:10:42,540
Galaxy alongside those radio Jets those

1675
01:10:46,430 --> 01:10:44,699
radio jets are doing their own thing and

1676
01:10:49,010 --> 01:10:46,440
you can't trace parts of the Galaxy to

1677
01:10:50,630 --> 01:10:49,020
be intertwined with the radio structure

1678
01:10:53,870 --> 01:10:50,640
in those cases but in these radio quiet

1679
01:10:56,450 --> 01:10:53,880
AGN you often see that the radio mission

1680
01:10:58,189 --> 01:10:56,460
is I keep saying intertwined with the

1681
01:11:00,350 --> 01:10:58,199
ionized gas which means it's always

1682
01:11:03,050 --> 01:11:00,360
lodged into the host plane the host

1683
01:11:04,610 --> 01:11:03,060
material of that Galaxy

1684
01:11:06,950 --> 01:11:04,620
wrong

1685
01:11:09,590 --> 01:11:06,960
all right uh any more questions we've

1686
01:11:11,930 --> 01:11:09,600
got there Grant yes um AC is keeping me

1687
01:11:15,110 --> 01:11:11,940
honest the first part of our previous

1688
01:11:18,830 --> 01:11:15,120

question uh what frequencies Do You

1689
01:11:20,689 --> 01:11:18,840
observe sorry sorry sorry sorry yep so

1690
01:11:23,870 --> 01:11:20,699
um these are typically you're looking at

1691
01:11:25,250 --> 01:11:23,880
this Continuum emission and so the

1692
01:11:26,990 --> 01:11:25,260
synchrotron is formed in a continual

1693
01:11:29,570 --> 01:11:27,000
emission that we observed with the vla

1694
01:11:31,010 --> 01:11:29,580
the very large array the jansky very

1695
01:11:34,669 --> 01:11:31,020
large array

1696
01:11:37,550 --> 01:11:34,679
um in New Mexico and we also can use the

1697
01:11:39,110 --> 01:11:37,560
very large or very long Baseline array

1698
01:11:40,610 --> 01:11:39,120
the vlba

1699
01:11:43,070 --> 01:11:40,620
um to look at that same Continuum at

1700
01:11:45,830 --> 01:11:43,080
even smaller scales and that's an array

1701
01:11:48,770 --> 01:11:45,840
of radio dishes from Hawaii to Florida

1702
01:11:51,169 --> 01:11:48,780
and so they're not it's an enormous uh

1703
01:11:53,390 --> 01:11:51,179
interferometer but it's uh typically

1704
01:11:55,250 --> 01:11:53,400
around like eight gigahertz

1705
01:12:02,030 --> 01:11:55,260
um if we want a number there so it's in

1706
01:12:02,040 --> 01:12:06,590
all right sounds cool

1707
01:12:09,590 --> 01:12:08,209
they're already asking when your second

1708
01:12:10,950 --> 01:12:09,600
talk is going to be after the next round

1709
01:12:14,990 --> 01:12:10,960
of observations

1710
01:12:22,550 --> 01:12:19,490
um are some Galactic Central areas more

1711
01:12:25,010 --> 01:12:22,560
dense they use the word clumpy causing

1712
01:12:31,790 --> 01:12:25,020
more fluctuations or more activity with

1713
01:12:38,750 --> 01:12:34,490

oh

1714
01:12:40,550 --> 01:12:38,760
sure uh yeah right I mean so it would

1715
01:12:43,430 --> 01:12:40,560
make sense logically but

1716
01:12:46,790 --> 01:12:43,440
the material

1717
01:12:48,890 --> 01:12:46,800
is generally gotta be fed in to the

1718
01:12:51,709 --> 01:12:48,900
black hole somehow so

1719
01:12:53,750 --> 01:12:51,719
it's usually some sort of gas Lane

1720
01:12:55,550 --> 01:12:53,760
that's falling into that's being that's

1721
01:12:59,990 --> 01:12:55,560
falling into the black hole for these

1722
01:13:03,830 --> 01:13:00,000
active Galactic nuclei uh but I mean

1723
01:13:05,570 --> 01:13:03,840
that could be formed from a merger or I

1724
01:13:07,370 --> 01:13:05,580
mean maybe you have a a ring of star

1725
01:13:08,990 --> 01:13:07,380
formation like a starburst ring that's

1726
01:13:11,570 --> 01:13:09,000
going on and that's creating a bunch of

1727
01:13:13,070 --> 01:13:11,580
wins uh off of the stars and that those

1728
01:13:15,410 --> 01:13:13,080
those winds are falling into the black

1729
01:13:16,130 --> 01:13:15,420
hole in the center

1730
01:13:18,890 --> 01:13:16,140
um

1731
01:13:20,990 --> 01:13:18,900
so typically I mean I don't know how

1732
01:13:23,689 --> 01:13:21,000
they differ how the environments differ

1733
01:13:26,090 --> 01:13:23,699
necessarily from quiescent galaxies

1734
01:13:27,709 --> 01:13:26,100
galaxies without an active Galaxy or an

1735
01:13:29,930 --> 01:13:27,719
active nucleus in the center so Frank

1736
01:13:31,970 --> 01:13:29,940
showed the whirlpool Galaxy early on

1737
01:13:33,590 --> 01:13:31,980
this beautiful Grand Design structure

1738
01:13:35,810 --> 01:13:33,600

with the dust lanes and stuff I don't

1739
01:13:37,430 --> 01:13:35,820
know why those dust Lanes aren't falling

1740
01:13:39,050 --> 01:13:37,440
into the supermassive black hole at the

1741
01:13:41,570 --> 01:13:39,060
center like

1742
01:13:43,370 --> 01:13:41,580
so I mean if if you told me that that

1743
01:13:44,990 --> 01:13:43,380
one was not an AGN and that another one

1744
01:13:47,390 --> 01:13:45,000
wasn't AGN I wouldn't be able to

1745
01:13:49,490 --> 01:13:47,400
necessarily tell just by looking at them

1746
01:13:51,590 --> 01:13:49,500
so

1747
01:13:54,050 --> 01:13:51,600
um yeah I don't I'm not really sure then

1748
01:13:56,270 --> 01:13:54,060
but you know the other thing is that the

1749
01:13:58,070 --> 01:13:56,280
feeding time scale for a supermassive

1750
01:14:01,010 --> 01:13:58,080
black hole is well beyond the human time

1751
01:14:04,250 --> 01:14:01,020
scale so I mean I guess there is sort of

1752
01:14:06,229 --> 01:14:04,260
a record of the feeding uh in the Jet

1753
01:14:08,810 --> 01:14:06,239
right as you said it takes time for that

1754
01:14:11,030 --> 01:14:08,820
jet to propagate or the the and the

1755
01:14:12,550 --> 01:14:11,040
energy depression yeah the radiation the

1756
01:14:16,070 --> 01:14:12,560
radiation

1757
01:14:17,930 --> 01:14:16,080
and so if it had an especially active

1758
01:14:20,570 --> 01:14:17,940
time of feeding then there would be an

1759
01:14:24,050 --> 01:14:20,580
especially intense region somewhere else

1760
01:14:30,229 --> 01:14:26,570
could you deconvolve the energy history

1761
01:14:33,530 --> 01:14:30,239
of the black hole phone so it's really

1762
01:14:37,010 --> 01:14:33,540
hard for me so like okay if you had just

1763
01:14:39,229 --> 01:14:37,020

a very even plane of gas that it was the

1764
01:14:41,030 --> 01:14:39,239
flashlight was shining onto and it was

1765
01:14:43,130 --> 01:14:41,040
all just like the same media like same

1766
01:14:45,410 --> 01:14:43,140
density and stuff if the the flux

1767
01:14:47,270 --> 01:14:45,420
intensity like changed over time then

1768
01:14:48,590 --> 01:14:47,280
you'd know like yeah this was an active

1769
01:14:50,689 --> 01:14:48,600
more active period where it was like

1770
01:14:54,169 --> 01:14:50,699
flaring and then it was less active here

1771
01:14:57,590 --> 01:14:54,179
but the the surface that you're shining

1772
01:15:00,169 --> 01:14:57,600
on is just so irregular too that it's

1773
01:15:02,689 --> 01:15:00,179
really hard for me to try to like pull

1774
01:15:04,669 --> 01:15:02,699
out where it was brighter and where it

1775
01:15:06,890 --> 01:15:04,679
was fainted but you're right yeah I mean

1776
01:15:09,470 --> 01:15:06,900
if you were able to do that you could

1777
01:15:11,209 --> 01:15:09,480
see how what the activity of the AGN was

1778
01:15:13,189 --> 01:15:11,219
like over time like oh it was eating a

1779
01:15:14,689 --> 01:15:13,199
bunch of stuff at this period and this

1780
01:15:16,630 --> 01:15:14,699
gas is a lot brighter than it should be

1781
01:15:19,130 --> 01:15:16,640
next to it than the gas next to it right

1782
01:15:21,470 --> 01:15:19,140
the variations in the intensity of the

1783
01:15:23,330 --> 01:15:21,480
flashlight of Doom that's right oh

1784
01:15:25,090 --> 01:15:23,340
that's like uh that's definitely a

1785
01:15:26,810 --> 01:15:25,100
Indiana Jones

1786
01:15:30,830 --> 01:15:26,820
it is

1787
01:15:34,010 --> 01:15:30,840
sorry is that a PhD thesis project right

1788
01:15:38,090 --> 01:15:36,370

I was thinking Mega made

1789
01:15:42,649 --> 01:15:38,100
all right

1790
01:15:46,010 --> 01:15:42,659
um so uh oh the ACF asked our previous

1791
01:15:47,330 --> 01:15:46,020
I got two two okay two more okay yep two

1792
01:15:47,930 --> 01:15:47,340
more okay

1793
01:15:49,970 --> 01:15:47,940
um

1794
01:15:53,090 --> 01:15:49,980
AC the asker of our previous question

1795
01:15:55,870 --> 01:15:53,100
says as an amateur radio astronomer he

1796
01:15:58,970 --> 01:15:55,880
observes the 21 centimeter natural

1797
01:16:01,729 --> 01:15:58,980
hydrogen emission from our galaxy at

1798
01:16:05,510 --> 01:16:01,739
about 1420 megahertz

1799
01:16:08,810 --> 01:16:05,520
right so that is a mission from a gas

1800
01:16:11,450 --> 01:16:08,820
line so that traces where the molecular

1801
01:16:13,430 --> 01:16:11,460
or the where the hydrogen gas is and so

1802
01:16:15,410 --> 01:16:13,440
as we were talking about with the

1803
01:16:18,169 --> 01:16:15,420
difference between Hubble and with James

1804
01:16:19,790 --> 01:16:18,179
Webb looking at these different colors

1805
01:16:23,149 --> 01:16:19,800
or different different frequencies are

1806
01:16:24,890 --> 01:16:23,159
gonna give us different dimensions of

1807
01:16:26,870 --> 01:16:24,900
the um the structure that's going on

1808
01:16:29,530 --> 01:16:26,880
there so that get that 21 centimeter

1809
01:16:32,810 --> 01:16:29,540
line is super helpful for like tracing

1810
01:16:34,669 --> 01:16:32,820
uh gas lanes and I know that we I

1811
01:16:37,370 --> 01:16:34,679
remember writing a paper that we were

1812
01:16:39,830 --> 01:16:37,380
able to say oh this AGN is active

1813
01:16:41,870 --> 01:16:39,840

because it's eating it's a creating

1814
01:16:44,570 --> 01:16:41,880
material from its neighbor over there

1815
01:16:47,570 --> 01:16:44,580
because we can trace the 21 centimeter

1816
01:16:50,090 --> 01:16:47,580
emission from that Galaxy to our galaxy

1817
01:16:52,310 --> 01:16:50,100
and so that but that's a differential

1818
01:16:54,530 --> 01:16:52,320
yes that that while it is a radio

1819
01:16:56,390 --> 01:16:54,540
emission mine it is telling us a

1820
01:16:58,729 --> 01:16:56,400
different uh bit of information that

1821
01:17:00,530 --> 01:16:58,739
we're that we use also to create the

1822
01:17:02,209 --> 01:17:00,540
story of understanding what's happening

1823
01:17:04,010 --> 01:17:02,219
each in each of these Scouts

1824
01:17:05,930 --> 01:17:04,020
yeah it's really important to understand

1825
01:17:08,750 --> 01:17:05,940
that these different emission lines come

1826
01:17:11,030 --> 01:17:08,760
from different physical processes uh you

1827
01:17:14,149 --> 01:17:11,040
know simple to understand that um you

1828
01:17:16,070 --> 01:17:14,159
know uh temp gas at 3000 degrees if it's

1829
01:17:18,649 --> 01:17:16,080
one emission line gas at 10 000 degrees

1830
01:17:20,810 --> 01:17:18,659
and it's a different emission line uh

1831
01:17:23,030 --> 01:17:20,820
same thing happens in the radio uh in

1832
01:17:24,649 --> 01:17:23,040
terms of uh the different radio

1833
01:17:26,810 --> 01:17:24,659
emissions and it doesn't have to be

1834
01:17:28,850 --> 01:17:26,820
different wave bands either like in the

1835
01:17:31,790 --> 01:17:28,860
infrared with James Webb you're looking

1836
01:17:33,830 --> 01:17:31,800
at like warm molecular gas which is like

1837
01:17:35,570 --> 01:17:33,840
a couple hundred degrees Kelvin and the

1838
01:17:39,890 --> 01:17:35,580

there's a mission lines right next to it

1839
01:17:41,570 --> 01:17:39,900
that is like quintupley ionized nitrogen

1840
01:17:44,149 --> 01:17:41,580
or neon or something like and it's right

1841
01:17:45,350 --> 01:17:44,159
there next to it so like if you look at

1842
01:17:46,729 --> 01:17:45,360
those two different lines they're going

1843
01:17:48,110 --> 01:17:46,739
to tell you completely different stories

1844
01:17:49,550 --> 01:17:48,120
even though they're almost the exact

1845
01:17:52,310 --> 01:17:49,560
same wavelength right

1846
01:17:53,930 --> 01:17:52,320
right and and as we emphasized it's the

1847
01:17:57,229 --> 01:17:53,940
underlying physics that you're getting a

1848
01:17:58,610 --> 01:17:57,239
handle on from the various things that

1849
01:18:01,430 --> 01:17:58,620
you were observing

1850
01:18:04,130 --> 01:18:01,440
okay you said you had one more Grant yes

1851
01:18:05,930 --> 01:18:04,140
yes we always get one snuck in really

1852
01:18:07,430 --> 01:18:05,940
good question and I'm gonna end on this

1853
01:18:09,850 --> 01:18:07,440
one okay

1854
01:18:13,010 --> 01:18:09,860
how have you found ways to keep

1855
01:18:15,050 --> 01:18:13,020
astronomy real and grounded for you I

1856
01:18:18,709 --> 01:18:15,060
found it can become academic over time

1857
01:18:24,709 --> 01:18:22,550
um so I always consider myself as I've

1858
01:18:27,169 --> 01:18:24,719
alluded to a couple times tonight like

1859
01:18:29,930 --> 01:18:27,179
I'm a detective I'm a gumshoe and like

1860
01:18:32,990 --> 01:18:29,940
I'm using all of this data from

1861
01:18:35,450 --> 01:18:33,000
different wave bands uh to tell these

1862
01:18:37,550 --> 01:18:35,460
stories and I I'm not a survey person I

1863
01:18:39,530 --> 01:18:37,560

don't look at hundreds or tens of

1864
01:18:42,530 --> 01:18:39,540
galaxies usually at a time I look at one

1865
01:18:45,110 --> 01:18:42,540
really hard and with like in the Optical

1866
01:18:46,070 --> 01:18:45,120
on the UV and the infrared and I use

1867
01:18:50,390 --> 01:18:46,080
that to

1868
01:18:52,610 --> 01:18:50,400
um uh glean some new facet of how AGN

1869
01:18:54,470 --> 01:18:52,620
work and how that really

1870
01:18:56,630 --> 01:18:54,480
um works with all of the rest of the AGM

1871
01:18:59,630 --> 01:18:56,640
that we look at right now I mean this

1872
01:19:01,669 --> 01:18:59,640
radio thing is just the worst because

1873
01:19:02,930 --> 01:19:01,679
I'm very convinced that this is what's

1874
01:19:06,709 --> 01:19:02,940
happening

1875
01:19:08,930 --> 01:19:06,719
um in these radio quiet AGN and so I'm

1876
01:19:10,790 --> 01:19:08,940
spending a bunch of time trying to

1877
01:19:12,649 --> 01:19:10,800
convince other people that this is the

1878
01:19:15,649 --> 01:19:12,659
case but I feel right now that I'm in

1879
01:19:19,310 --> 01:19:15,659
the majority and the minority so

1880
01:19:21,530 --> 01:19:19,320
um that is my my quest right now is to

1881
01:19:23,810 --> 01:19:21,540
have folks acknowledge that this is

1882
01:19:26,930 --> 01:19:23,820
potentially what's going on and how

1883
01:19:29,030 --> 01:19:26,940
useful it would be if that is the case

1884
01:19:31,010 --> 01:19:29,040
um because then we can see like if we

1885
01:19:33,350 --> 01:19:31,020
just do a radio survey of this Continuum

1886
01:19:36,590 --> 01:19:33,360
Mission we can see uh we can take a

1887
01:19:38,450 --> 01:19:36,600
census of how many AGN are shocking or

1888
01:19:39,649 --> 01:19:38,460

compressing the gas of their host

1889
01:19:45,649 --> 01:19:39,659
galaxies

1890
01:19:48,470 --> 01:19:45,659
when people model how outflows work in

1891
01:19:50,390 --> 01:19:48,480
AGN they can say well we should have the

1892
01:19:52,490 --> 01:19:50,400
outflows run into the host plane

1893
01:19:55,610 --> 01:19:52,500
approximately 40 percent of the time

1894
01:19:57,950 --> 01:19:55,620
because that fisher guy found that the

1895
01:20:00,470 --> 01:19:57,960
extended radio structure happens about

1896
01:20:01,910 --> 01:20:00,480
40 percent of the time in these galaxies

1897
01:20:03,830 --> 01:20:01,920
that would suggest that that's where

1898
01:20:05,570 --> 01:20:03,840
positive feedback is happening and we'll

1899
01:20:08,390 --> 01:20:05,580
have to incorporate that into our models

1900
01:20:10,669 --> 01:20:08,400
so so that's what's keeping me going

1901
01:20:12,590 --> 01:20:10,679
right now

1902
01:20:16,010 --> 01:20:12,600
um and so that's going to keep happening

1903
01:20:18,350 --> 01:20:16,020
until the money runs out or something

1904
01:20:20,510 --> 01:20:18,360
else is more attractive to me but uh

1905
01:20:22,189 --> 01:20:20,520
that's how wide I'm doing that's a good

1906
01:20:23,870 --> 01:20:22,199
way to think of it though

1907
01:20:26,030 --> 01:20:23,880
but that's the fun thing about science

1908
01:20:27,830 --> 01:20:26,040
is there's always another problem to

1909
01:20:29,570 --> 01:20:27,840
solve if you get bored with this problem

1910
01:20:32,689 --> 01:20:29,580
which you know this is quite a fun

1911
01:20:35,090 --> 01:20:32,699
problem I I must say but there's always

1912
01:20:37,130 --> 01:20:35,100
yet other problems to go you know so you

1913
01:20:38,810 --> 01:20:37,140

can just say okay let's cut that's the

1914
01:20:40,729 --> 01:20:38,820
end of this season let's move on to the

1915
01:20:42,830 --> 01:20:40,739
next season of you know galactic

1916
01:20:44,810 --> 01:20:42,840
Detective

1917
01:20:47,510 --> 01:20:44,820
that's right I I like I like the

1918
01:20:49,310 --> 01:20:47,520
specific work the the word you that you

1919
01:20:51,110 --> 01:20:49,320
use just Quest

1920
01:20:52,910 --> 01:20:51,120
because it just makes me think that it's

1921
01:20:54,410 --> 01:20:52,920
not like another project it's not

1922
01:20:58,850 --> 01:20:54,420
another thing you're discovering it's a

1923
01:21:01,070 --> 01:20:58,860
side quest like yeah like here

1924
01:21:03,410 --> 01:21:01,080
we're gonna figure out

1925
01:21:05,630 --> 01:21:03,420
and what it's Illuminating for us and

1926
01:21:07,729 --> 01:21:05,640
then we that's just part of the bigger

1927
01:21:09,470 --> 01:21:07,739
picture but uh and then there's always

1928
01:21:10,850 --> 01:21:09,480
another Quest on the horizon that you're

1929
01:21:12,050 --> 01:21:10,860
like you're finishing this one and

1930
01:21:13,610 --> 01:21:12,060
you're like what am I gonna do after

1931
01:21:15,410 --> 01:21:13,620
this and then you're like that one I

1932
01:21:17,689 --> 01:21:15,420
have to go work on that idea next time

1933
01:21:19,729 --> 01:21:17,699
yep that's all right well we wish you

1934
01:21:21,770 --> 01:21:19,739
the best of luck in your continuing

1935
01:21:23,390 --> 01:21:21,780
series of quests

1936
01:21:25,610 --> 01:21:23,400
um and you know when you when you get

1937
01:21:26,530 --> 01:21:25,620
the answers come on back and and let us

1938
01:21:31,910 --> 01:21:26,540

know

1939
01:21:34,970 --> 01:21:31,920
next month uh April 4th exploring Rocky

1940
01:21:36,950 --> 01:21:34,980
worlds on the precipice of a new

1941
01:21:39,290 --> 01:21:36,960
frontier Catherine Bennett from the

1942
01:21:41,470 --> 01:21:39,300
Space Telescope science is dude we will

1943
01:21:44,870 --> 01:21:41,480
see you then thank you all for for