
NASA
Kimberly Weaver
Astrophysicist, NASA Goddard Space Flight Center

1
00:00:09,750 --> 00:00:07,909
hi i'm trent perado public affairs

2
00:00:11,669 --> 00:00:09,760
officer for nasa's science mission

3
00:00:13,110 --> 00:00:11,679
directorate in washington dc like to

4
00:00:14,549 --> 00:00:13,120
welcome you to today's news conference

5
00:00:16,070 --> 00:00:14,559
where we'll be discussing the latest

6
00:00:17,990 --> 00:00:16,080
discovery by the chandra x-ray

7
00:00:19,910 --> 00:00:18,000
observatory about an exceptional object

8
00:00:21,750 --> 00:00:19,920
in our cosmic neighborhood

9
00:00:23,670 --> 00:00:21,760
chandra is one of nasa's so-called great

10
00:00:25,589 --> 00:00:23,680
observatories it allows scientists from

11
00:00:27,029 --> 00:00:25,599
around the world to obtain x-ray images

12
00:00:28,790 --> 00:00:27,039
of exotic environments to better

13
00:00:30,870 --> 00:00:28,800

understand the structure and evolution

14
00:00:32,389 --> 00:00:30,880
of our universe for those joining us

15
00:00:34,110 --> 00:00:32,399
online you can find out more information

16
00:00:37,030 --> 00:00:34,120
on

17
00:00:38,470 --> 00:00:37,040
www.nasa.gov forward slash chandra

18
00:00:40,389 --> 00:00:38,480
as for the order of events today we'll

19
00:00:41,830 --> 00:00:40,399
have five panelists joining us each

20
00:00:43,350 --> 00:00:41,840
we'll give a short briefing and then

21
00:00:45,110 --> 00:00:43,360
we'll open the phone lines for questions

22
00:00:46,790 --> 00:00:45,120
and answers i'd like to take a brief

23
00:00:49,190 --> 00:00:46,800
moment just to welcome and introduce the

24
00:00:50,790 --> 00:00:49,200
panelists first we have john morse

25
00:00:53,350 --> 00:00:50,800
director of the astrophysics division

26
00:00:55,830 --> 00:00:53,360
nasa headquarters in washington next uh

27
00:00:57,750 --> 00:00:55,840
dan patnod astrophysicist at the harvard

28
00:00:59,430 --> 00:00:57,760
smithsonian center for astrophysics in

29
00:01:01,750 --> 00:00:59,440
cambridge massachusetts

30
00:01:03,270 --> 00:01:01,760
next avi loeb astrophysicist at the

31
00:01:05,990 --> 00:01:03,280
harvard smithsonian center for

32
00:01:08,230 --> 00:01:06,000
astrophysics in cambridge massachusetts

33
00:01:09,750 --> 00:01:08,240
kim weaver astrophysicist at the goddard

34
00:01:12,070 --> 00:01:09,760
space flight center in greenbelt

35
00:01:13,830 --> 00:01:12,080
maryland and joining us by phone is alex

36
00:01:16,149 --> 00:01:13,840
filippinko astrophysicist at the

37
00:01:17,270 --> 00:01:16,159
university of california berkeley

38
00:01:21,270 --> 00:01:17,280

and with that i'll hand off the

39
00:01:25,429 --> 00:01:23,030
thanks trent

40
00:01:27,830 --> 00:01:25,439
now some missions are like good wine

41
00:01:29,910 --> 00:01:27,840
they improve with time

42
00:01:33,109 --> 00:01:29,920
and the chandra x-ray observatory is

43
00:01:34,310 --> 00:01:33,119
certainly one of our gems

44
00:01:36,149 --> 00:01:34,320
if we could have the first graphic

45
00:01:39,990 --> 00:01:36,159
please

46
00:01:43,990 --> 00:01:40,000
now more than 11 years ago

47
00:01:47,429 --> 00:01:44,000
chandra was put into orbit by the sts-93

48
00:01:47,439 --> 00:01:52,069
and here we show the launch video

49
00:01:58,069 --> 00:01:54,469
back in 1999

50
00:02:00,469 --> 00:01:58,079
and then this is the deploy on orbit

51
00:02:02,789 --> 00:02:00,479
and that uh booster

52
00:02:04,950 --> 00:02:02,799
stage right there put chandra into its

53
00:02:07,510 --> 00:02:04,960
final science orbit which takes it all

54
00:02:10,389 --> 00:02:07,520
the way up to 44 000 miles above the

55
00:02:12,630 --> 00:02:10,399
earth and then swoops back in

56
00:02:15,110 --> 00:02:12,640
every orbit and it spends most of its

57
00:02:16,710 --> 00:02:15,120
time doing its science away from the

58
00:02:18,869 --> 00:02:16,720
earth

59
00:02:19,990 --> 00:02:18,879
now even starting with the first light

60
00:02:21,510 --> 00:02:20,000
image

61
00:02:23,589 --> 00:02:21,520
there has been

62
00:02:25,910 --> 00:02:23,599
extraordinary wealth of data coming from

63
00:02:27,589 --> 00:02:25,920

this truly great observatory

64
00:02:30,150 --> 00:02:27,599
so let's briefly look at some of the

65
00:02:31,509 --> 00:02:30,160
iconic data coming from chandra over the

66
00:02:34,070 --> 00:02:31,519
past decade

67
00:02:36,550 --> 00:02:34,080
in the first graphic we have the

68
00:02:38,710 --> 00:02:36,560
cassiopeia a supernova remnant

69
00:02:40,949 --> 00:02:38,720
and this is an exploded star in the

70
00:02:45,350 --> 00:02:40,959
neighborhood of the sun

71
00:02:48,390 --> 00:02:45,360
not too far away and it shows us uh

72
00:02:51,190 --> 00:02:48,400
very graphically how the elements

73
00:02:53,030 --> 00:02:51,200
are born inside the stars and then

74
00:02:54,869 --> 00:02:53,040
distributed out into the interstellar

75
00:02:57,110 --> 00:02:54,879
medium and the colors in this image

76
00:03:00,390 --> 00:02:57,120
actually tell us what the elements are

77
00:03:02,309 --> 00:03:00,400
whether it's oxygen or iron and so on in

78
00:03:04,390 --> 00:03:02,319
the next image

79
00:03:06,710 --> 00:03:04,400
this is the crab nebula

80
00:03:08,790 --> 00:03:06,720
and this shows swirling electrons around

81
00:03:10,630 --> 00:03:08,800
the pulsar at the middle of that

82
00:03:12,550 --> 00:03:10,640
exploded star

83
00:03:15,270 --> 00:03:12,560
in the next image

84
00:03:16,149 --> 00:03:15,280
we have the center of our galaxy

85
00:03:19,910 --> 00:03:16,159
and

86
00:03:22,229 --> 00:03:19,920
supermassive black holes at the centers

87
00:03:24,789 --> 00:03:22,239
of galaxies including here in

88
00:03:25,990 --> 00:03:24,799

sagittarius in our own center of the

89
00:03:27,830 --> 00:03:26,000
milky way

90
00:03:30,149 --> 00:03:27,840
in the next image

91
00:03:32,710 --> 00:03:30,159
we have the bullet cluster

92
00:03:34,470 --> 00:03:32,720
here in shown in the red

93
00:03:36,550 --> 00:03:34,480
chandra has mapped the x-rays coming

94
00:03:38,949 --> 00:03:36,560
from the hot normal matter

95
00:03:41,910 --> 00:03:38,959
as galaxy clusters collide out in the

96
00:03:44,789 --> 00:03:41,920
cosmos and it is shown how it differs

97
00:03:47,270 --> 00:03:44,799
from the blue which is mapping of the

98
00:03:49,110 --> 00:03:47,280
dark matter in this region

99
00:03:51,030 --> 00:03:49,120
and it shows us how the normal matter

100
00:03:52,470 --> 00:03:51,040
and the dark matter actually behave

101
00:03:54,229 --> 00:03:52,480
differently

102
00:03:56,710 --> 00:03:54,239
it doesn't tell us what dark matter is

103
00:03:58,229 --> 00:03:56,720
but it's a very important clue as to its

104
00:04:01,030 --> 00:03:58,239
nature

105
00:04:03,030 --> 00:04:01,040
and in the final image

106
00:04:06,149 --> 00:04:03,040
this is a deep field

107
00:04:08,309 --> 00:04:06,159
showing us the x-ray glow from objects

108
00:04:10,149 --> 00:04:08,319
such as distant quasars it tells us

109
00:04:12,630 --> 00:04:10,159
about the distribution

110
00:04:15,110 --> 00:04:12,640
of black holes throughout the universe

111
00:04:17,110 --> 00:04:15,120
and chandra is even responsible

112
00:04:18,629 --> 00:04:17,120
for making the only other independent

113
00:04:20,229 --> 00:04:18,639

measurement of the dark energy in the

114
00:04:22,550 --> 00:04:20,239
universe

115
00:04:24,870 --> 00:04:22,560
so it's not surprising that chandra

116
00:04:26,710 --> 00:04:24,880
scores well and in our most recent

117
00:04:28,710 --> 00:04:26,720
senior review

118
00:04:30,550 --> 00:04:28,720
of operating missions and astrophysics

119
00:04:32,870 --> 00:04:30,560
it was right at the very top

120
00:04:35,030 --> 00:04:32,880
for its science impact

121
00:04:36,469 --> 00:04:35,040
and so now let's hear about another one

122
00:04:38,629 --> 00:04:36,479
of the science

123
00:04:39,909 --> 00:04:38,639
results from chandra let me turn it over

124
00:04:40,790 --> 00:04:39,919
to dan

125
00:04:42,790 --> 00:04:40,800
thank you

126
00:04:44,629 --> 00:04:42,800
so today what we'd like to do is report

127
00:04:46,469 --> 00:04:44,639
on evidence for the detection of what

128
00:04:48,710 --> 00:04:46,479
might be the youngest black hole in

129
00:04:50,950 --> 00:04:48,720
observed in our own cosmic neighborhood

130
00:04:52,710 --> 00:04:50,960
born in a core collapse supernova this

131
00:04:54,950 --> 00:04:52,720
uh supernova was observed about 30 years

132
00:04:56,790 --> 00:04:54,960
ago now core collapse supernova are

133
00:04:59,270 --> 00:04:56,800
associated with the deaths of massive

134
00:05:00,870 --> 00:04:59,280
stars and it's believed that at least

135
00:05:02,710 --> 00:05:00,880
some of these events can result in the

136
00:05:04,469 --> 00:05:02,720
formation of black holes

137
00:05:06,230 --> 00:05:04,479
results such as this might actually be

138
00:05:07,510 --> 00:05:06,240

important because we don't know what the

139
00:05:09,749 --> 00:05:07,520
dividing line is between those

140
00:05:12,150 --> 00:05:09,759
supernovas which form black holes and

141
00:05:13,749 --> 00:05:12,160
those which form neutron stars this is

142
00:05:15,749 --> 00:05:13,759
something my colleague avi will discuss

143
00:05:18,629 --> 00:05:15,759
in a few minutes now this particular

144
00:05:21,430 --> 00:05:18,639
supernova supernova 1979c

145
00:05:23,590 --> 00:05:21,440
was observed in april 1979 by an amateur

146
00:05:25,909 --> 00:05:23,600
astronomer named gus johnson who's a

147
00:05:28,070 --> 00:05:25,919
school teacher from nearby swanton

148
00:05:30,710 --> 00:05:28,080
maryland he was observing the nearby

149
00:05:33,270 --> 00:05:30,720
galaxy m100 which is shown here

150
00:05:34,710 --> 00:05:33,280
in the digital sky survey and then again

151
00:05:36,629 --> 00:05:34,720
in the vlt

152
00:05:39,590 --> 00:05:36,639
and now as you see in x-rays where

153
00:05:41,270 --> 00:05:39,600
supernova 1979 c is actually seen he was

154
00:05:43,590 --> 00:05:41,280
observing it

155
00:05:45,350 --> 00:05:43,600
just because this is what he liked to do

156
00:05:46,870 --> 00:05:45,360
and at the time his was only the third

157
00:05:48,230 --> 00:05:46,880
discovery by direct detection of a

158
00:05:50,310 --> 00:05:48,240
supernova

159
00:05:51,510 --> 00:05:50,320
so in x-rays

160
00:05:53,990 --> 00:05:51,520
it's been observed with several

161
00:05:56,150 --> 00:05:54,000
observatories first with einstein x-ray

162
00:05:59,590 --> 00:05:56,160
telescope in 1980 which actually didn't

163
00:06:02,390 --> 00:05:59,600

detect it and then later on in 1995 with

164
00:06:04,469 --> 00:06:02,400
the rosat x-ray telescope now between

165
00:06:06,629 --> 00:06:04,479
observations with rosat and now there

166
00:06:09,909 --> 00:06:06,639
have been several observations done with

167
00:06:11,830 --> 00:06:09,919
chandra xmm newton and also swift

168
00:06:13,830 --> 00:06:11,840
and while it isn't unusual to observe

169
00:06:16,230 --> 00:06:13,840
x-rays coming from a young evolving

170
00:06:17,749 --> 00:06:16,240
supernova what is interesting is that

171
00:06:20,950 --> 00:06:17,759
the x-ray emission from this particular

172
00:06:23,029 --> 00:06:20,960
object has remained remarkably steady

173
00:06:25,350 --> 00:06:23,039
in addition while it's also been steady

174
00:06:27,110 --> 00:06:25,360
it's also been extremely bright

175
00:06:28,469 --> 00:06:27,120
and we interpret this high luminosity or

176
00:06:30,950 --> 00:06:28,479
high brightness as evidence for

177
00:06:33,270 --> 00:06:30,960
accretion of supernova material back

178
00:06:34,790 --> 00:06:33,280
onto the black hole now when we speak of

179
00:06:36,550 --> 00:06:34,800
accretion what we're talking about is

180
00:06:37,590 --> 00:06:36,560
material that's being fed back onto

181
00:06:39,830 --> 00:06:37,600
something

182
00:06:41,830 --> 00:06:39,840
and in the case here as it's accreted

183
00:06:43,270 --> 00:06:41,840
onto the black hole it heats up to very

184
00:06:45,909 --> 00:06:43,280
high temperatures and becomes very

185
00:06:47,830 --> 00:06:45,919
bright in x-rays in the case here we can

186
00:06:49,749 --> 00:06:47,840
use the brightness

187
00:06:51,270 --> 00:06:49,759
of the accretion onto the black hole to

188
00:06:53,110 --> 00:06:51,280

find out that this

189
00:06:55,909 --> 00:06:53,120
black hole probably has a mass of around

190
00:06:57,749 --> 00:06:55,919
five times the mass of our sun

191
00:06:59,510 --> 00:06:57,759
so the question becomes why is it that

192
00:07:00,870 --> 00:06:59,520
we think that some of the x-ray emission

193
00:07:02,629 --> 00:07:00,880
that we're observing or most of the

194
00:07:05,029 --> 00:07:02,639
x-ray emission that we're observing is

195
00:07:07,430 --> 00:07:05,039
coming from accretion onto a black hole

196
00:07:09,270 --> 00:07:07,440
and not by other some physical mechanism

197
00:07:11,990 --> 00:07:09,280
well as it turns out there are actually

198
00:07:14,230 --> 00:07:12,000
several mechanisms for x-ray emission

199
00:07:15,990 --> 00:07:14,240
from a supernova one is that you have

200
00:07:17,909 --> 00:07:16,000
the blast wave just expanding out into

201
00:07:19,510 --> 00:07:17,919
the progenitor as wind

202
00:07:21,189 --> 00:07:19,520
and in this case the blast wave will

203
00:07:23,350 --> 00:07:21,199
heat the surrounding material to high

204
00:07:25,430 --> 00:07:23,360
temperatures the problem with our that

205
00:07:26,870 --> 00:07:25,440
interpretation that we found in this

206
00:07:29,029 --> 00:07:26,880
case is that

207
00:07:30,550 --> 00:07:29,039
as the blast wave expands the x-ray

208
00:07:32,629 --> 00:07:30,560
emission should actually decrease with

209
00:07:34,150 --> 00:07:32,639
time because it's expanding the blast

210
00:07:35,990 --> 00:07:34,160
waves expanding into less and less

211
00:07:37,670 --> 00:07:36,000
material

212
00:07:39,270 --> 00:07:37,680
if we observed that the x-ray emission

213
00:07:40,870 --> 00:07:39,280

was fading we might actually be

214
00:07:42,950 --> 00:07:40,880
comfortable with that interpretation but

215
00:07:45,189 --> 00:07:42,960
as it is we weren't

216
00:07:47,350 --> 00:07:45,199
so another possibility is that when this

217
00:07:49,749 --> 00:07:47,360
star exploded it formed what's called a

218
00:07:51,510 --> 00:07:49,759
magnetar now magnetar is just a special

219
00:07:53,270 --> 00:07:51,520
type of neutron star with an extremely

220
00:07:55,670 --> 00:07:53,280
high magnetic field

221
00:07:57,990 --> 00:07:55,680
and the idea is that as this magnetar is

222
00:08:00,469 --> 00:07:58,000
formed it loses some of its rotational

223
00:08:02,550 --> 00:08:00,479
power to the uh

224
00:08:05,110 --> 00:08:02,560
it loses some of its rotational energy

225
00:08:07,270 --> 00:08:05,120
and powers the light curve in x-rays

226
00:08:08,550 --> 00:08:07,280
the problem here is that once again you

227
00:08:10,629 --> 00:08:08,560
know the x-ray emission is actually

228
00:08:11,589 --> 00:08:10,639
going to be assumed to decrease with

229
00:08:13,670 --> 00:08:11,599
time

230
00:08:15,430 --> 00:08:13,680
and we developed a model for what the

231
00:08:17,029 --> 00:08:15,440
magnetar emission should look like over

232
00:08:19,270 --> 00:08:17,039
time and we found that we're about a

233
00:08:21,270 --> 00:08:19,280
factor of 10 times brighter than what

234
00:08:22,629 --> 00:08:21,280
the model predicts

235
00:08:23,830 --> 00:08:22,639
so

236
00:08:25,189 --> 00:08:23,840
excuse me

237
00:08:27,110 --> 00:08:25,199
now while our observations are

238
00:08:28,710 --> 00:08:27,120

consistent with that of an accreting

239
00:08:31,029 --> 00:08:28,720
black hole there's actually another

240
00:08:32,230 --> 00:08:31,039
intriguing possibility and that is that

241
00:08:33,990 --> 00:08:32,240
we're looking at something called a

242
00:08:35,909 --> 00:08:34,000
pulsar wind nebula such as the crab

243
00:08:37,509 --> 00:08:35,919
nebula in our own galaxy

244
00:08:38,790 --> 00:08:37,519
in this case instead of looking at

245
00:08:41,029 --> 00:08:38,800
something that's actually accreting

246
00:08:43,110 --> 00:08:41,039
material we have a rapidly spinning

247
00:08:44,550 --> 00:08:43,120
neutron star that's sending out very

248
00:08:45,990 --> 00:08:44,560
high energy electrons and other

249
00:08:47,030 --> 00:08:46,000
particles out into the surrounding

250
00:08:48,949 --> 00:08:47,040
material

251
00:08:51,430 --> 00:08:48,959
and in that case we're actually looking

252
00:08:53,670 --> 00:08:51,440
at the emission from that star rather

253
00:08:55,910 --> 00:08:53,680
we're actually looking from the wind

254
00:08:57,509 --> 00:08:55,920
rather than from the accretion

255
00:08:59,829 --> 00:08:57,519
in any case whether it's a pulsar or

256
00:09:01,829 --> 00:08:59,839
nebula or a black hole we're looking at

257
00:09:04,310 --> 00:09:01,839
one of these objects in its infancy and

258
00:09:05,829 --> 00:09:04,320
that in and of itself is exciting

259
00:09:08,150 --> 00:09:05,839
so we have ideas as to how we can

260
00:09:09,990 --> 00:09:08,160
actually test these various theories and

261
00:09:12,070 --> 00:09:10,000
we have observations which are coming up

262
00:09:13,670 --> 00:09:12,080
in the near future and if we find that

263
00:09:15,829 --> 00:09:13,680

this particular object is still as

264
00:09:18,790 --> 00:09:15,839
bright as it's been for the last

265
00:09:19,910 --> 00:09:18,800
almost 20 years at this point in x-rays

266
00:09:23,110 --> 00:09:19,920
when you account for the fact that it

267
00:09:25,030 --> 00:09:23,120
was only redetected in 1995.

268
00:09:26,470 --> 00:09:25,040
we plan on maybe getting a longer

269
00:09:28,389 --> 00:09:26,480
observation where we can actually look

270
00:09:30,389 --> 00:09:28,399
at a detailed spectrum of this object

271
00:09:32,310 --> 00:09:30,399
and test whether the x-ray emission is

272
00:09:35,190 --> 00:09:32,320
coming from some sort of central compact

273
00:09:36,389 --> 00:09:35,200
object or the blast wave or possibly or

274
00:09:37,910 --> 00:09:36,399
likely a

275
00:09:40,150 --> 00:09:37,920
combination of both

276
00:09:41,990 --> 00:09:40,160
so with that i'd like to turn over

277
00:09:44,790 --> 00:09:42,000
the speaker to

278
00:09:46,550 --> 00:09:44,800
avi thank you

279
00:09:48,070 --> 00:09:46,560
so we are here to discuss a question

280
00:09:51,829 --> 00:09:48,080
that is often

281
00:09:53,590 --> 00:09:51,839
asked in hollywood how do stars end

282
00:09:55,110 --> 00:09:53,600
their life except we're dealing with

283
00:09:57,590 --> 00:09:55,120
real stars

284
00:09:59,269 --> 00:09:57,600
and when the star is 10 times more

285
00:10:01,590 --> 00:09:59,279
massive than the sun or even more than

286
00:10:04,150 --> 00:10:01,600
that

287
00:10:05,269 --> 00:10:04,160
the star the core of the star may

288
00:10:06,949 --> 00:10:05,279

collapse

289
00:10:09,430 --> 00:10:06,959
at the end of its life

290
00:10:11,990 --> 00:10:09,440
once the nuclear fuel is consumed in

291
00:10:13,990 --> 00:10:12,000
near the center of the star

292
00:10:15,910 --> 00:10:14,000
the core collapses loses pressure

293
00:10:17,509 --> 00:10:15,920
support and collapses upon itself due to

294
00:10:20,310 --> 00:10:17,519
its own gravity

295
00:10:22,870 --> 00:10:20,320
and it can end up in one of two ways

296
00:10:25,269 --> 00:10:22,880
either it makes a neutron star which is

297
00:10:27,590 --> 00:10:25,279
the densest form of matter

298
00:10:30,150 --> 00:10:27,600
that we know about it has the density

299
00:10:33,190 --> 00:10:30,160
similar to that of an atomic nucleus and

300
00:10:34,069 --> 00:10:33,200
a size comparable to that of a big city

301
00:10:36,470 --> 00:10:34,079
or

302
00:10:37,590 --> 00:10:36,480
it ends up in a black hole

303
00:10:40,150 --> 00:10:37,600
which is

304
00:10:41,190 --> 00:10:40,160
an object to which you can get in but

305
00:10:42,870 --> 00:10:41,200
can never

306
00:10:45,430 --> 00:10:42,880
get out of

307
00:10:47,269 --> 00:10:45,440
sort of the ultimate prison

308
00:10:49,350 --> 00:10:47,279
and theorists theoretical

309
00:10:50,470 --> 00:10:49,360
astrophysicists were debating for many

310
00:10:52,310 --> 00:10:50,480
years

311
00:10:54,310 --> 00:10:52,320
about the

312
00:10:56,710 --> 00:10:54,320
boundary between

313
00:10:59,350 --> 00:10:56,720

a star that can make a black hole and a

314
00:11:02,069 --> 00:10:59,360
star that can end up as a neutron star

315
00:11:04,150 --> 00:11:02,079
and the fate of the star depends on many

316
00:11:06,310 --> 00:11:04,160
factors most importantly the mass of the

317
00:11:08,069 --> 00:11:06,320
stars

318
00:11:10,550 --> 00:11:08,079
it can also depend on whether the star

319
00:11:12,069 --> 00:11:10,560
has a companion whether it rotates and

320
00:11:16,550 --> 00:11:12,079
so forth

321
00:11:19,750 --> 00:11:16,560
the progenitor of supernova 1979c

322
00:11:22,550 --> 00:11:19,760
uh is estimated uh to have been a star

323
00:11:24,470 --> 00:11:22,560
with 20 solar masses on the boundary uh

324
00:11:26,069 --> 00:11:24,480
the theories postulated for the

325
00:11:29,030 --> 00:11:26,079
transition between a neutron star and a

326
00:11:30,630 --> 00:11:29,040
black hole and so it could very well

327
00:11:33,670 --> 00:11:30,640
have been the progenitor appropriate for

328
00:11:35,829 --> 00:11:33,680
making a black hole

329
00:11:37,910 --> 00:11:35,839
this particular supernova belongs to a

330
00:11:40,630 --> 00:11:37,920
rare type of

331
00:11:42,949 --> 00:11:40,640
these explosive events

332
00:11:45,829 --> 00:11:42,959
that includes about six percent of all

333
00:11:49,110 --> 00:11:45,839
core collapse supernova these are called

334
00:11:49,910 --> 00:11:49,120
type two linear uh supernova in which

335
00:11:53,350 --> 00:11:49,920
the

336
00:11:56,069 --> 00:11:53,360
steadily

337
00:11:59,030 --> 00:11:56,079
by many orders of magnitude indifference

338
00:12:01,269 --> 00:11:59,040

for the more typical types of supernovae

339
00:12:02,230 --> 00:12:01,279
that reach a peak decline a little bit

340
00:12:04,470 --> 00:12:02,240
and then

341
00:12:07,269 --> 00:12:04,480
remain steady for a long while these are

342
00:12:10,470 --> 00:12:07,279
called type 2 plateau

343
00:12:11,990 --> 00:12:10,480
now about 20 percent of all core

344
00:12:15,269 --> 00:12:12,000
collapse supernova

345
00:12:16,230 --> 00:12:15,279
are believed to end up as black holes

346
00:12:18,310 --> 00:12:16,240
and

347
00:12:21,190 --> 00:12:18,320
it is believed that stars more massive

348
00:12:24,389 --> 00:12:21,200
than about 20 or 25 solar masses

349
00:12:26,710 --> 00:12:24,399
end their life that way if our

350
00:12:31,030 --> 00:12:26,720
interpretation is correct and indeed

351
00:12:33,269 --> 00:12:31,040
supernova 1979c ended up as a black hole

352
00:12:35,190 --> 00:12:33,279
then of course it's the first time

353
00:12:37,030 --> 00:12:35,200
that we are seeing

354
00:12:38,949 --> 00:12:37,040
a black hole being born

355
00:12:41,430 --> 00:12:38,959
in a normal supernova

356
00:12:44,230 --> 00:12:41,440
it has been conjectured for a while that

357
00:12:46,550 --> 00:12:44,240
black holes do form in explosive events

358
00:12:48,790 --> 00:12:46,560
that take place across the universe

359
00:12:50,710 --> 00:12:48,800
these are called gamma-ray bursts

360
00:12:52,310 --> 00:12:50,720
in these events

361
00:12:53,829 --> 00:12:52,320
the core of the star may collapse to

362
00:12:57,430 --> 00:12:53,839
make a black hole

363
00:12:59,750 --> 00:12:57,440

and the black hole produces jets of

364
00:13:01,670 --> 00:12:59,760
matter moving at speed as the speed

365
00:13:04,069 --> 00:13:01,680
close to the speed of light

366
00:13:06,470 --> 00:13:04,079
and those jets penetrate through the

367
00:13:09,190 --> 00:13:06,480
envelope of the star and eventually

368
00:13:11,990 --> 00:13:09,200
get out so that if an observer is lined

369
00:13:14,069 --> 00:13:12,000
up with the jet it would see

370
00:13:16,389 --> 00:13:14,079
a gamma-ray flash and we call these

371
00:13:19,190 --> 00:13:16,399
gamma-ray bursts we see such flashes

372
00:13:21,590 --> 00:13:19,200
roughly once a day coming

373
00:13:23,829 --> 00:13:21,600
from the edge of the universe

374
00:13:25,990 --> 00:13:23,839
however in this particular event there

375
00:13:27,990 --> 00:13:26,000
is no evidence for a gamma ray burst so

376
00:13:31,750 --> 00:13:28,000
it's the first time we see a black hole

377
00:13:33,350 --> 00:13:31,760
being born in a normal supernova

378
00:13:36,230 --> 00:13:33,360
now

379
00:13:38,629 --> 00:13:36,240
the luminosity that we observe in x-rays

380
00:13:40,629 --> 00:13:38,639
is close to the limiting luminosity that

381
00:13:43,189 --> 00:13:40,639
the black hole can have

382
00:13:45,670 --> 00:13:43,199
so if you feed a black hole

383
00:13:47,910 --> 00:13:45,680
with a lot of masses in this case the

384
00:13:51,910 --> 00:13:47,920
black hole may be fed

385
00:13:53,030 --> 00:13:51,920
by a disk of material surrounding it

386
00:13:55,269 --> 00:13:53,040
either

387
00:13:58,310 --> 00:13:55,279
as a result of material that was left

388
00:14:01,110 --> 00:13:58,320

behind from the supernova explosion or

389
00:14:03,189 --> 00:14:01,120
as a result of a binary star companion

390
00:14:05,829 --> 00:14:03,199
that donates mass

391
00:14:08,150 --> 00:14:05,839
to this black hole

392
00:14:10,230 --> 00:14:08,160
in that case

393
00:14:12,550 --> 00:14:10,240
if the luminosity coming from the

394
00:14:14,069 --> 00:14:12,560
vicinity of the black hole exceeds

395
00:14:14,870 --> 00:14:14,079
a certain limit

396
00:14:20,949 --> 00:14:14,880
the

397
00:14:23,189 --> 00:14:20,959
allow it

398
00:14:24,629 --> 00:14:23,199
to accrete onto the black hole and so

399
00:14:26,710 --> 00:14:24,639
there is this very natural

400
00:14:29,110 --> 00:14:26,720
characteristic luminosity that you would

401
00:14:31,670 --> 00:14:29,120
expect from a black hole that is fed

402
00:14:32,710 --> 00:14:31,680
well and this is roughly the luminosity

403
00:14:35,590 --> 00:14:32,720
that we see

404
00:14:38,629 --> 00:14:35,600
for the typical black hole masses

405
00:14:41,189 --> 00:14:38,639
of 5 to 10 solar masses that one expects

406
00:14:43,430 --> 00:14:41,199
from such events

407
00:14:46,310 --> 00:14:43,440
now it will take the black hole about 40

408
00:14:48,790 --> 00:14:46,320
million years to double its mass and so

409
00:14:50,949 --> 00:14:48,800
we cannot really trace a change in the

410
00:14:53,829 --> 00:14:50,959
mass of the black hole during the course

411
00:14:55,829 --> 00:14:53,839
of the observations the 31 years that we

412
00:14:58,310 --> 00:14:55,839
have observed this source but the fact

413
00:15:00,069 --> 00:14:58,320

that the luminosity is steady is a clear

414
00:15:01,750 --> 00:15:00,079
indication

415
00:15:04,230 --> 00:15:01,760
that we might be

416
00:15:05,350 --> 00:15:04,240
seeing a black hole accreting at its

417
00:15:07,269 --> 00:15:05,360
limiting

418
00:15:08,550 --> 00:15:07,279
accretion rate

419
00:15:10,629 --> 00:15:08,560
and

420
00:15:13,110 --> 00:15:10,639
in particular

421
00:15:15,509 --> 00:15:13,120
what we have are photos of this

422
00:15:17,829 --> 00:15:15,519
this source

423
00:15:19,189 --> 00:15:17,839
during the first 30 years during its

424
00:15:21,030 --> 00:15:19,199
infancy

425
00:15:22,790 --> 00:15:21,040
these photos are labeled by the age of

426
00:15:25,269 --> 00:15:22,800
the source even though it took them a

427
00:15:27,990 --> 00:15:25,279
long time to reach us

428
00:15:30,069 --> 00:15:28,000
as we observe them today

429
00:15:33,990 --> 00:15:30,079
if this is indeed a black hole then

430
00:15:35,990 --> 00:15:34,000
there are several important implications

431
00:15:38,230 --> 00:15:36,000
first

432
00:15:40,710 --> 00:15:38,240
to the basic question of how

433
00:15:43,030 --> 00:15:40,720
supernovae explode uh there are two

434
00:15:45,430 --> 00:15:43,040
possible energy sources for um an

435
00:15:46,870 --> 00:15:45,440
explosion it could either be a central

436
00:15:48,710 --> 00:15:46,880
engine

437
00:15:49,829 --> 00:15:48,720
just like the black hole that somehow

438
00:15:52,949 --> 00:15:49,839

releases

439
00:15:55,189 --> 00:15:52,959
energy into its vicinity and powers it

440
00:15:56,470 --> 00:15:55,199
that's how a gamma ray burst

441
00:15:59,030 --> 00:15:56,480
takes place

442
00:16:01,269 --> 00:15:59,040
or it could be a radioactive material

443
00:16:04,069 --> 00:16:01,279
that is produced in the supernova

444
00:16:08,310 --> 00:16:04,079
that is powering um the light curve of

445
00:16:10,790 --> 00:16:08,320
the supernova and so understanding the

446
00:16:12,629 --> 00:16:10,800
the way that supernovae explode and

447
00:16:14,629 --> 00:16:12,639
which fraction of them end up as black

448
00:16:16,550 --> 00:16:14,639
holes and which fraction end up as

449
00:16:19,110 --> 00:16:16,560
neutron stars is very important for our

450
00:16:21,590 --> 00:16:19,120
theoretical understanding of these

451
00:16:23,990 --> 00:16:21,600
important events

452
00:16:26,870 --> 00:16:24,000
theories for many years had a difficult

453
00:16:28,150 --> 00:16:26,880
time exploding massive stars on the

454
00:16:30,230 --> 00:16:28,160
computer

455
00:16:32,550 --> 00:16:30,240
and it's quite possible that

456
00:16:36,150 --> 00:16:32,560
they were right that in fact

457
00:16:38,629 --> 00:16:36,160
a fraction of those explosive events end

458
00:16:41,189 --> 00:16:38,639
up eventually imploding and making a

459
00:16:43,110 --> 00:16:41,199
black hole we don't know the relative

460
00:16:44,069 --> 00:16:43,120
statistics of black holes and neutron

461
00:16:46,310 --> 00:16:44,079
stars

462
00:16:48,389 --> 00:16:46,320
to a very good precision at the moment

463
00:16:51,110 --> 00:16:48,399

and so observing events like that are

464
00:16:53,749 --> 00:16:51,120
very important in terms of calibrating

465
00:16:55,110 --> 00:16:53,759
the statistics

466
00:16:57,749 --> 00:16:55,120
in addition

467
00:17:00,470 --> 00:16:57,759
black hole and neutron star binaries are

468
00:17:02,069 --> 00:17:00,480
important sources of gravitational waves

469
00:17:04,309 --> 00:17:02,079
and there are observatories being

470
00:17:05,990 --> 00:17:04,319
constructed to detect these waves and so

471
00:17:07,590 --> 00:17:06,000
we would like of course to know the

472
00:17:09,270 --> 00:17:07,600
abundance of black holes and neutron

473
00:17:11,429 --> 00:17:09,280
stars

474
00:17:13,750 --> 00:17:11,439
and overall we're dealing with the

475
00:17:15,909 --> 00:17:13,760
properties of matter at extreme

476
00:17:19,270 --> 00:17:15,919
conditions at very high densities close

477
00:17:20,949 --> 00:17:19,280
to that of an atomic nucleus

478
00:17:23,189 --> 00:17:20,959
and we cannot really reproduce these

479
00:17:25,750 --> 00:17:23,199
conditions in the laboratory and so by

480
00:17:28,230 --> 00:17:25,760
observing the sky we're able to learn

481
00:17:29,990 --> 00:17:28,240
about environments that cannot be

482
00:17:33,110 --> 00:17:30,000
reproduced in the lab

483
00:17:35,270 --> 00:17:33,120
and that can only be observed out there

484
00:17:38,150 --> 00:17:35,280
in the universe

485
00:17:40,150 --> 00:17:38,160
of course if we go back in time to the

486
00:17:42,150 --> 00:17:40,160
very first stars for example the

487
00:17:44,549 --> 00:17:42,160
conditions there were different

488
00:17:47,510 --> 00:17:44,559

it's quite possible as some theorists

489
00:17:49,909 --> 00:17:47,520
argue that massive stars were much more

490
00:17:51,750 --> 00:17:49,919
abundant at early times and so the

491
00:17:53,830 --> 00:17:51,760
formation of black holes

492
00:17:57,110 --> 00:17:53,840
may have been much more

493
00:17:59,990 --> 00:17:57,120
frequent at early cosmic times

494
00:18:01,830 --> 00:18:00,000
and i will turn this the stage to kim

495
00:18:04,870 --> 00:18:01,840
thanks avi thanks stan for explaining

496
00:18:06,950 --> 00:18:04,880
this exciting result um what is it that

497
00:18:09,590 --> 00:18:06,960
really matters in terms of this result

498
00:18:12,070 --> 00:18:09,600
it's not just that possibly we have

499
00:18:13,990 --> 00:18:12,080
found the youngest nearby black hole it

500
00:18:15,830 --> 00:18:14,000
is a young black hole but what's really

501
00:18:16,950 --> 00:18:15,840
exciting about it is that we know the

502
00:18:19,110 --> 00:18:16,960
exact

503
00:18:21,669 --> 00:18:19,120
birth date of the black hole we have

504
00:18:24,310 --> 00:18:21,679
found for the first time possibly the

505
00:18:26,789 --> 00:18:24,320
true birth date of a black hole and you

506
00:18:29,029 --> 00:18:26,799
may ask well aren't black holes in the

507
00:18:29,990 --> 00:18:29,039
early universe younger perhaps than this

508
00:18:31,669 --> 00:18:30,000
one

509
00:18:34,549 --> 00:18:31,679
certainly there are black holes that are

510
00:18:36,390 --> 00:18:34,559
forming um all the time and in the early

511
00:18:38,630 --> 00:18:36,400
universe there might be very young black

512
00:18:41,029 --> 00:18:38,640
holes but do we know their exact age do

513
00:18:42,950 --> 00:18:41,039

we know exactly how old they are no it's

514
00:18:44,710 --> 00:18:42,960
very difficult to do that

515
00:18:47,190 --> 00:18:44,720
when light has traveled billions and

516
00:18:49,029 --> 00:18:47,200
billions of years to reach us it's hard

517
00:18:51,430 --> 00:18:49,039
to say exactly when a black hole that

518
00:18:53,510 --> 00:18:51,440
we're looking at was born so this is a

519
00:18:55,750 --> 00:18:53,520
very important result to be able to

520
00:18:58,630 --> 00:18:55,760
pinpoint the birth date of a black hole

521
00:19:00,549 --> 00:18:58,640
for the first time and for me in terms

522
00:19:03,029 --> 00:19:00,559
of studying black holes what's exciting

523
00:19:05,270 --> 00:19:03,039
about it is that we know it's very young

524
00:19:08,150 --> 00:19:05,280
it is in its infancy if it is a black

525
00:19:10,150 --> 00:19:08,160
hole and we want to watch how this

526
00:19:12,470 --> 00:19:10,160
system evolves and changes in its

527
00:19:14,950 --> 00:19:12,480
youthful stages from when it's first

528
00:19:17,270 --> 00:19:14,960
born to when it goes into a child and a

529
00:19:18,950 --> 00:19:17,280
teenager and gets older and it creates

530
00:19:21,029 --> 00:19:18,960
more material because that's how we

531
00:19:22,150 --> 00:19:21,039
understand the physics of black hole

532
00:19:24,150 --> 00:19:22,160
systems

533
00:19:26,150 --> 00:19:24,160
so that's very important the other thing

534
00:19:28,710 --> 00:19:26,160
that's kind of neat about this story is

535
00:19:31,430 --> 00:19:28,720
it is a story it's a story of science in

536
00:19:33,430 --> 00:19:31,440
action and you you know you've heard a

537
00:19:36,230 --> 00:19:33,440
little bit about the the description of

538
00:19:38,870 --> 00:19:36,240

the observations when it was observed it

539
00:19:41,669 --> 00:19:38,880
was observed many times since with uh

540
00:19:44,390 --> 00:19:41,679
nasa satellites and other uh

541
00:19:46,950 --> 00:19:44,400
observatories and so astronomers around

542
00:19:49,669 --> 00:19:46,960
the globe have taken images and and data

543
00:19:51,669 --> 00:19:49,679
from this object and over time have put

544
00:19:54,070 --> 00:19:51,679
together this story which is sort of

545
00:19:56,070 --> 00:19:54,080
like a detective story taking pieces of

546
00:19:58,070 --> 00:19:56,080
the puzzle and putting them together and

547
00:20:00,310 --> 00:19:58,080
finally determining that yes indeed

548
00:20:01,990 --> 00:20:00,320
we've almost solved the puzzle now we

549
00:20:05,350 --> 00:20:02,000
just need a few more pieces so we're

550
00:20:06,390 --> 00:20:05,360
very close to understanding the true uh

551
00:20:09,029 --> 00:20:06,400
source

552
00:20:10,789 --> 00:20:09,039
the genesis of this this compact object

553
00:20:13,750 --> 00:20:10,799
in the center of this supernova

554
00:20:15,190 --> 00:20:13,760
explosion so that's very exciting um

555
00:20:16,870 --> 00:20:15,200
it's in its infancy we want to

556
00:20:18,870 --> 00:20:16,880
understand accretion and energy

557
00:20:20,390 --> 00:20:18,880
production in this object

558
00:20:22,470 --> 00:20:20,400
the thing that's interesting about

559
00:20:24,950 --> 00:20:22,480
supernova 1979c

560
00:20:27,430 --> 00:20:24,960
is that it's very difficult to see these

561
00:20:30,070 --> 00:20:27,440
objects even if there were many of them

562
00:20:33,590 --> 00:20:30,080
out there in our galaxy for example when

563
00:20:36,310 --> 00:20:33,600

a supernova goes off it it

564
00:20:38,390 --> 00:20:36,320
fills its region with material and so it

565
00:20:40,950 --> 00:20:38,400
might be difficult to look inside and

566
00:20:43,830 --> 00:20:40,960
see through the obscuration to see the

567
00:20:46,070 --> 00:20:43,840
black hole being formed also the light

568
00:20:49,110 --> 00:20:46,080
the integrated light from that supernova

569
00:20:51,190 --> 00:20:49,120
event might be too bright and might get

570
00:20:53,190 --> 00:20:51,200
in the way of seeing the light from the

571
00:20:55,350 --> 00:20:53,200
black hole accretion anyway so it

572
00:20:57,510 --> 00:20:55,360
probably takes about four to five years

573
00:21:00,070 --> 00:20:57,520
before you can really see the x-ray

574
00:21:02,310 --> 00:21:00,080
light coming out of the material around

575
00:21:04,630 --> 00:21:02,320
the black hole that makes this object

576
00:21:06,630 --> 00:21:04,640
actually perfect for detecting because

577
00:21:09,510 --> 00:21:06,640
it's roughly the right age to be able to

578
00:21:11,990 --> 00:21:09,520
see that x-ray signature pop out so it's

579
00:21:14,470 --> 00:21:12,000
a wonderful opportunity for astronomers

580
00:21:16,630 --> 00:21:14,480
to look at these young systems and i

581
00:21:18,630 --> 00:21:16,640
hope we can find many many more of them

582
00:21:21,110 --> 00:21:18,640
and now that we know a way to do that by

583
00:21:22,789 --> 00:21:21,120
using x-ray data hopefully astronomers

584
00:21:24,870 --> 00:21:22,799
will begin to look through the data and

585
00:21:27,110 --> 00:21:24,880
see if we can find more

586
00:21:29,430 --> 00:21:27,120
so what is the implication for finding

587
00:21:31,669 --> 00:21:29,440
more baby black holes in the universe

588
00:21:35,350 --> 00:21:31,679

again this is the first direct evidence

589
00:21:37,830 --> 00:21:35,360
for one the first strong direct evidence

590
00:21:39,669 --> 00:21:37,840
so to me it's sort of a new population

591
00:21:41,350 --> 00:21:39,679
of youthful objects

592
00:21:42,870 --> 00:21:41,360
you know i'd like to be able to see more

593
00:21:44,630 --> 00:21:42,880
young black holes because i want to

594
00:21:46,870 --> 00:21:44,640
understand what's happening right after

595
00:21:49,750 --> 00:21:46,880
they're born and they probably are very

596
00:21:52,950 --> 00:21:49,760
common another important tool here is

597
00:21:55,029 --> 00:21:52,960
the x-ray spectrum itself we see what we

598
00:21:57,430 --> 00:21:55,039
believe to be the x-ray spectrum of

599
00:22:00,470 --> 00:21:57,440
accretion around a black hole there are

600
00:22:02,070 --> 00:22:00,480
many objects out there that are compact

601
00:22:04,870 --> 00:22:02,080
that we think might be black holes but

602
00:22:07,270 --> 00:22:04,880
we're not sure and the only data we have

603
00:22:09,590 --> 00:22:07,280
are x-ray spectra so if we really know

604
00:22:11,669 --> 00:22:09,600
that this is one then we can take this

605
00:22:13,510 --> 00:22:11,679
spectrum and match it to the other x-ray

606
00:22:16,149 --> 00:22:13,520
specter and see if they look the same

607
00:22:18,710 --> 00:22:16,159
and if they do that's a very good

608
00:22:20,950 --> 00:22:18,720
indirect way to say oh these other

609
00:22:23,110 --> 00:22:20,960
things are also black holes so i think

610
00:22:26,310 --> 00:22:23,120
that this discovery is going to help

611
00:22:28,470 --> 00:22:26,320
astronomers add to our census of the

612
00:22:30,549 --> 00:22:28,480
number of black holes that we know about

613
00:22:35,110 --> 00:22:30,559

in the universe

614
00:22:40,390 --> 00:22:37,590
said this is an exciting discovery a

615
00:22:42,310 --> 00:22:40,400
very young black hole born just 31 years

616
00:22:44,230 --> 00:22:42,320
ago as seen by us

617
00:22:47,270 --> 00:22:44,240
so here we have essentially a baby

618
00:22:49,350 --> 00:22:47,280
picture of a stellar mass black hole

619
00:22:51,830 --> 00:22:49,360
one that is about five times the mass of

620
00:22:53,510 --> 00:22:51,840
the sun those are the stellar mass ones

621
00:22:56,310 --> 00:22:53,520
as opposed to the supermassive black

622
00:22:58,230 --> 00:22:56,320
holes in the centers of galaxies

623
00:23:01,190 --> 00:22:58,240
now we know of several dozen stellar

624
00:23:02,950 --> 00:23:01,200
mass black holes in our milky way galaxy

625
00:23:05,110 --> 00:23:02,960
and there are probably millions of them

626
00:23:06,470 --> 00:23:05,120
in each big galaxy but we don't know

627
00:23:08,149 --> 00:23:06,480
their ages

628
00:23:10,630 --> 00:23:08,159
most of them are probably millions or

629
00:23:13,110 --> 00:23:10,640
even billions of years old so here is

630
00:23:15,669 --> 00:23:13,120
one whose age we actually know

631
00:23:18,070 --> 00:23:15,679
and by continuing to observe this object

632
00:23:20,710 --> 00:23:18,080
we will be able to study how young black

633
00:23:22,470 --> 00:23:20,720
holes behave and especially how they

634
00:23:25,990 --> 00:23:22,480
swallow gas from their immediate

635
00:23:27,909 --> 00:23:26,000
surroundings how they accrete this gas

636
00:23:31,350 --> 00:23:27,919
now as avi said it's important to

637
00:23:33,190 --> 00:23:31,360
distinguish supernova 1979 c

638
00:23:35,669 --> 00:23:33,200

from another way of producing stellar

639
00:23:38,310 --> 00:23:35,679
mass black holes the so-called gamma-ray

640
00:23:39,990 --> 00:23:38,320
bursts or grbs

641
00:23:42,549 --> 00:23:40,000
now gamma-ray bursts are sometimes

642
00:23:44,950 --> 00:23:42,559
called the birth cries of black holes

643
00:23:46,630 --> 00:23:44,960
and it's true we we do indeed think that

644
00:23:47,669 --> 00:23:46,640
many of them produce stellar mass black

645
00:23:49,510 --> 00:23:47,679
holes

646
00:23:51,510 --> 00:23:49,520
but we still don't have any direct

647
00:23:53,909 --> 00:23:51,520
evidence that they produce black holes

648
00:23:56,630 --> 00:23:53,919
we have not yet detected the putative

649
00:23:58,470 --> 00:23:56,640
black holes in these objects

650
00:24:01,510 --> 00:23:58,480
gamma-ray bursts produce black holes

651
00:24:03,750 --> 00:24:01,520
through the merging of two neutron stars

652
00:24:06,789 --> 00:24:03,760
or through the collapse of a single

653
00:24:09,110 --> 00:24:06,799
extremely massive rotating star

654
00:24:11,990 --> 00:24:09,120
but such events are extremely rare

655
00:24:14,390 --> 00:24:12,000
supernova 1979c on the other hand may be

656
00:24:17,510 --> 00:24:14,400
more a more typical way in which massive

657
00:24:19,269 --> 00:24:17,520
stars produce black holes

658
00:24:22,070 --> 00:24:19,279
now another interesting difference is

659
00:24:24,310 --> 00:24:22,080
that grbs generally occur billions of

660
00:24:25,190 --> 00:24:24,320
light years away and billions of years

661
00:24:27,990 --> 00:24:25,200
ago

662
00:24:31,830 --> 00:24:28,000
whereas supernova 1979 c occurred in the

663
00:24:34,230 --> 00:24:31,840

relatively nearby beautiful galaxy m100

664
00:24:36,390 --> 00:24:34,240
in the virgo cluster only about 50

665
00:24:38,630 --> 00:24:36,400
million light years away

666
00:24:42,310 --> 00:24:38,640
so in a sense this object is almost in

667
00:24:43,990 --> 00:24:42,320
our backyard compared with typical grbs

668
00:24:45,510 --> 00:24:44,000
we'll be able to study it in much more

669
00:24:47,990 --> 00:24:45,520
detail we'll be able to study the

670
00:24:51,269 --> 00:24:48,000
secretion process

671
00:24:53,269 --> 00:24:51,279
as avi mentioned supernova 1979c was a

672
00:24:55,750 --> 00:24:53,279
relatively rare type of supernova a

673
00:24:58,070 --> 00:24:55,760
so-called type ii linear

674
00:24:59,909 --> 00:24:58,080
these kinds of exploding stars are only

675
00:25:01,590 --> 00:24:59,919
about five or six percent of core

676
00:25:03,590 --> 00:25:01,600
collapse supernovae

677
00:25:05,430 --> 00:25:03,600
and moreover only a small fraction of

678
00:25:06,630 --> 00:25:05,440
them probably produce black holes at

679
00:25:08,549 --> 00:25:06,640
their center

680
00:25:10,789 --> 00:25:08,559
the others produce a very dense type of

681
00:25:12,710 --> 00:25:10,799
star known as a neutron star

682
00:25:15,830 --> 00:25:12,720
but astronomers don't yet know what the

683
00:25:17,510 --> 00:25:15,840
dividing line in mass is between the

684
00:25:18,470 --> 00:25:17,520
types of stars that produce neutron

685
00:25:20,870 --> 00:25:18,480
stars

686
00:25:22,390 --> 00:25:20,880
versus those that produce black holes we

687
00:25:23,909 --> 00:25:22,400
just don't know what that dividing line

688
00:25:26,549 --> 00:25:23,919

is but it's important because we want to

689
00:25:28,070 --> 00:25:26,559
understand how exactly black holes are

690
00:25:30,950 --> 00:25:28,080
produced

691
00:25:33,430 --> 00:25:30,960
the star that formed supernova 79c

692
00:25:34,870 --> 00:25:33,440
probably had an initial mass of about 20

693
00:25:37,110 --> 00:25:34,880
solar masses

694
00:25:39,269 --> 00:25:37,120
and this might be very close to this

695
00:25:41,190 --> 00:25:39,279
dividing line in mass

696
00:25:43,830 --> 00:25:41,200
now there are certainly other variables

697
00:25:45,669 --> 00:25:43,840
such as how mass is lost from the star

698
00:25:47,909 --> 00:25:45,679
prior to the explosion

699
00:25:49,590 --> 00:25:47,919
and whether the star is in a binary

700
00:25:52,310 --> 00:25:49,600
stellar system

701
00:25:55,029 --> 00:25:52,320
supernova 1979c in fact may have been in

702
00:25:56,710 --> 00:25:55,039
a binary stellar system but in any case

703
00:25:57,750 --> 00:25:56,720
the supernova will help astronomers

704
00:25:59,990 --> 00:25:57,760
determine

705
00:26:03,669 --> 00:26:00,000
which stellar explosions make black

706
00:26:05,269 --> 00:26:03,679
holes and which ones make neutron stars

707
00:26:07,350 --> 00:26:05,279
and this will also tell us about the

708
00:26:09,110 --> 00:26:07,360
nature of matter at very high densities

709
00:26:10,789 --> 00:26:09,120
and we can't study that in terrestrial

710
00:26:13,190 --> 00:26:10,799
laboratories you know you can't go to

711
00:26:15,669 --> 00:26:13,200
the hardware store and buy a neutron

712
00:26:17,909 --> 00:26:15,679
star whereas here we have a case that

713
00:26:19,909 --> 00:26:17,919

may be telling us the dividing line at

714
00:26:22,149 --> 00:26:19,919
which point a ball of matter becomes

715
00:26:24,630 --> 00:26:22,159
unstable and gravitationally collapses

716
00:26:26,390 --> 00:26:24,640
to form a black hole

717
00:26:29,029 --> 00:26:26,400
the final possibility i want to mention

718
00:26:29,990 --> 00:26:29,039
is that as dan said this might be

719
00:26:33,190 --> 00:26:30,000
powered

720
00:26:35,510 --> 00:26:33,200
by a pulsar wind nebula not necessarily

721
00:26:37,750 --> 00:26:35,520
by accretion onto a black hole but to me

722
00:26:39,750 --> 00:26:37,760
that would also be interesting because

723
00:26:41,350 --> 00:26:39,760
this would be the youngest known pulsar

724
00:26:43,590 --> 00:26:41,360
wind nebula

725
00:26:45,830 --> 00:26:43,600
now a great example of such an object is

726
00:26:47,669 --> 00:26:45,840
the crab nebula which is nearly a

727
00:26:49,590 --> 00:26:47,679
thousand years old it was the remnant

728
00:26:51,510 --> 00:26:49,600
it's the remnant of the supernova that

729
00:26:54,230 --> 00:26:51,520
was studied by chinese astronomers in

730
00:26:56,470 --> 00:26:54,240
the year 1054. and it's been studied by

731
00:26:59,590 --> 00:26:56,480
astronomers in great detail

732
00:27:02,789 --> 00:26:59,600
what we see in supernova 1979 see may be

733
00:27:04,390 --> 00:27:02,799
a very young version of the crab nebula

734
00:27:07,510 --> 00:27:04,400
and it will help us understand the

735
00:27:08,870 --> 00:27:07,520
evolution of such objects through time

736
00:27:11,269 --> 00:27:08,880
so i'm pretty excited about this

737
00:27:13,830 --> 00:27:11,279
discovery regardless of whether it turns

738
00:27:15,990 --> 00:27:13,840

out to be a young black hole or a pulsar

739
00:27:20,950 --> 00:27:16,000
wind nebula we should keep on observing

740
00:27:22,789 --> 00:27:20,960
it to learn more about it thanks

741
00:27:24,230 --> 00:27:22,799
okay great uh thank you very much alex

742
00:27:26,470 --> 00:27:24,240
uh now we're going to move on to the

743
00:27:28,230 --> 00:27:26,480
question and answer session uh for all

744
00:27:30,070 --> 00:27:28,240
participants please identify yourself

745
00:27:32,310 --> 00:27:30,080
and your media affiliation before asking

746
00:27:34,389 --> 00:27:32,320
your question uh and if possible direct

747
00:27:36,230 --> 00:27:34,399
your question to a specific panelist for

748
00:27:37,669 --> 00:27:36,240
those joining by phone you can signal

749
00:27:39,510 --> 00:27:37,679
the operator that you have a question by

750
00:27:40,549 --> 00:27:39,520
pushing the star one keys on your

751
00:27:42,389 --> 00:27:40,559
telephone

752
00:27:43,669 --> 00:27:42,399
um and we have a number of press online

753
00:27:46,149 --> 00:27:43,679
with us so i'd ask you to please limit

754
00:27:47,750 --> 00:27:46,159
yourself to one question to start

755
00:27:49,669 --> 00:27:47,760
i understand that we have a question on

756
00:27:51,190 --> 00:27:49,679
the phone from seth bornstein from the

757
00:27:54,149 --> 00:27:51,200
associated press

758
00:27:57,669 --> 00:27:55,669
thank you so much for doing this i guess

759
00:27:59,430 --> 00:27:57,679
this would be for avi or

760
00:28:02,870 --> 00:27:59,440
or kimberly weaver

761
00:28:06,630 --> 00:28:02,880
um it's a two-part question then first

762
00:28:09,590 --> 00:28:06,640
is if this is in indeed a uh

763
00:28:12,230 --> 00:28:09,600

uh if if it is not uh uh black hole and

764
00:28:14,710 --> 00:28:12,240
as a pulsar wind nebula our pulsar wind

765
00:28:18,070 --> 00:28:14,720
nebulas more rare than black holes in

766
00:28:19,830 --> 00:28:18,080
the in our um in our cosmic neighborhood

767
00:28:21,510 --> 00:28:19,840
um in other words which is more rare and

768
00:28:24,230 --> 00:28:21,520
then the second part is

769
00:28:28,070 --> 00:28:24,240
would this if this is a black hole would

770
00:28:29,590 --> 00:28:28,080
the this be the smallest mass of a star

771
00:28:32,870 --> 00:28:29,600
that led to a black hole that we've

772
00:28:37,750 --> 00:28:32,880
observed so far with the 20 mass

773
00:28:39,269 --> 00:28:37,760
of the star that involved here thank you

774
00:28:40,630 --> 00:28:39,279
so um

775
00:28:43,590 --> 00:28:40,640
this is avi

776
00:28:44,389 --> 00:28:43,600
um pulsar win the nebular much more

777
00:28:48,950 --> 00:28:44,399
common

778
00:28:50,789 --> 00:28:48,960
black hole remnants

779
00:28:52,870 --> 00:28:50,799
simply because only a small fraction of

780
00:28:53,990 --> 00:28:52,880
all core collapse supernovae

781
00:28:55,510 --> 00:28:54,000
end up

782
00:28:58,549 --> 00:28:55,520
in a black hole

783
00:29:00,230 --> 00:28:58,559
and that's of course a theoretical

784
00:29:02,389 --> 00:29:00,240
estimate but it's also

785
00:29:04,310 --> 00:29:02,399
backed by data we have

786
00:29:06,230 --> 00:29:04,320
on the frequency by which we observe

787
00:29:10,190 --> 00:29:06,240
evidence for black holes

788
00:29:13,590 --> 00:29:10,200

in binary star systems

789
00:29:15,430 --> 00:29:13,600
now um

790
00:29:18,310 --> 00:29:15,440
to answer um

791
00:29:20,149 --> 00:29:18,320
the second um question you had

792
00:29:25,990 --> 00:29:20,159
um

793
00:29:28,310 --> 00:29:26,000
terms of this being possibly the

794
00:29:30,230 --> 00:29:28,320
smallest mass star that has ever made a

795
00:29:32,710 --> 00:29:30,240
stellar size black hole we don't know

796
00:29:34,870 --> 00:29:32,720
the answer to that because it's it's not

797
00:29:37,029 --> 00:29:34,880
clear what the masses of the progenitors

798
00:29:40,149 --> 00:29:37,039
really are and this is a piece of data

799
00:29:42,710 --> 00:29:40,159
that's going to help us understand that

800
00:29:44,950 --> 00:29:42,720
sort of limiting mass between making a

801
00:29:46,870 --> 00:29:44,960
black hole and a neutron star so we we

802
00:29:48,549 --> 00:29:46,880
don't know the answer and these data

803
00:29:52,070 --> 00:29:48,559
will lead us to the answer to that

804
00:29:54,870 --> 00:29:53,269
okay great

805
00:29:56,470 --> 00:29:54,880
uh thanks very much let me just check

806
00:29:59,350 --> 00:29:56,480
and see if there are any questions here

807
00:30:00,710 --> 00:29:59,360
in the uh in the audience

808
00:30:03,110 --> 00:30:00,720
no

809
00:30:05,990 --> 00:30:03,120
back to the phones uh just reminder hit

810
00:30:12,149 --> 00:30:06,000
uh to hit star one uh on your telephone

811
00:30:17,669 --> 00:30:15,190
okay uh kristen minogue from science

812
00:30:19,510 --> 00:30:17,679
magazine you're on

813
00:30:20,870 --> 00:30:19,520

go ahead thank you for talking to us

814
00:30:22,789 --> 00:30:20,880
today

815
00:30:25,269 --> 00:30:22,799
this could be a very obvious question so

816
00:30:27,669 --> 00:30:25,279
if it is i apologize for it um

817
00:30:29,830 --> 00:30:27,679
i'm curious since the supernova occurred

818
00:30:31,510 --> 00:30:29,840
in a galaxy 50 million light years away

819
00:30:33,110 --> 00:30:31,520
from earth i don't know the age of the

820
00:30:35,269 --> 00:30:33,120
black hole is like 30 years old how is

821
00:30:38,149 --> 00:30:35,279
that possible

822
00:30:40,470 --> 00:30:38,159
i'll handle this so this is dan

823
00:30:42,549 --> 00:30:40,480
so when we talk about how old the black

824
00:30:44,389 --> 00:30:42,559
hole is or how old the um

825
00:30:47,269 --> 00:30:44,399
the supernova is we're actually

826
00:30:50,389 --> 00:30:47,279
referring to how old it is with regards

827
00:30:52,230 --> 00:30:50,399
to when we first observed it so

828
00:30:54,710 --> 00:30:52,240
when we say it's 30 years ago it means

829
00:30:55,510 --> 00:30:54,720
that that's when we saw it

830
00:30:58,389 --> 00:30:55,520
now

831
00:30:59,830 --> 00:30:58,399
the galaxy is is 50 million light years

832
00:31:01,110 --> 00:30:59,840
ago away

833
00:31:02,710 --> 00:31:01,120
so

834
00:31:05,350 --> 00:31:02,720
um

835
00:31:07,509 --> 00:31:05,360
in its own frame of reference that

836
00:31:08,310 --> 00:31:07,519
occurred 50 million years ago

837
00:31:11,430 --> 00:31:08,320
so

838
00:31:13,509 --> 00:31:11,440

another way to put it is um

839
00:31:16,549 --> 00:31:13,519
if you are assembling a photo album of

840
00:31:19,350 --> 00:31:16,559
your family you can have pictures in it

841
00:31:20,470 --> 00:31:19,360
that are labeled by the age of the

842
00:31:22,870 --> 00:31:20,480
person

843
00:31:24,789 --> 00:31:22,880
rather than by the time it took

844
00:31:27,190 --> 00:31:24,799
uh these pictures to be put together in

845
00:31:28,230 --> 00:31:27,200
the album so in our case

846
00:31:30,710 --> 00:31:28,240
it took

847
00:31:34,310 --> 00:31:30,720
the picture to arrive to us a lot of

848
00:31:36,230 --> 00:31:34,320
time but what we see is a picture of the

849
00:31:38,310 --> 00:31:36,240
object of the source when it was very

850
00:31:42,070 --> 00:31:38,320
young and that's what we refer to as the

851
00:31:46,070 --> 00:31:43,990
okay great thank you the next question

852
00:31:48,870 --> 00:31:46,080
comes from mark kaufman washington post

853
00:31:53,029 --> 00:31:50,950
yes sir thank you very much uh just

854
00:31:54,470 --> 00:31:53,039
trying to understand something about the

855
00:31:56,870 --> 00:31:54,480
presence of the

856
00:31:58,950 --> 00:31:56,880
um of the gamma-ray burst

857
00:32:00,710 --> 00:31:58,960
type supernova

858
00:32:03,509 --> 00:32:00,720
and black holes that would be coming

859
00:32:06,470 --> 00:32:03,519
from them uh do those also exist and

860
00:32:09,110 --> 00:32:06,480
they occur in the milky way or is this

861
00:32:11,269 --> 00:32:09,120
something that is you know with further

862
00:32:13,190 --> 00:32:11,279
back in time and as a result would be

863
00:32:15,590 --> 00:32:13,200

very different in that sense

864
00:32:17,669 --> 00:32:15,600
um this is avi um

865
00:32:19,990 --> 00:32:17,679
gamma ray bursts occur in all galaxies

866
00:32:22,230 --> 00:32:20,000
they just occur much much less

867
00:32:24,549 --> 00:32:22,240
frequently than supernova only a small

868
00:32:26,230 --> 00:32:24,559
fraction of all

869
00:32:28,070 --> 00:32:26,240
collapses of

870
00:32:31,110 --> 00:32:28,080
massive stars end up in a gamma ray

871
00:32:31,909 --> 00:32:31,120
burst so in a galaxy like our own we

872
00:32:33,990 --> 00:32:31,919
have

873
00:32:34,789 --> 00:32:34,000
to wait a long time before we will see

874
00:32:36,230 --> 00:32:34,799
one

875
00:32:38,470 --> 00:32:36,240
gamma ray burst

876
00:32:41,590 --> 00:32:38,480
we only have to wait a century or so

877
00:32:42,789 --> 00:32:41,600
before we see a new supernova

878
00:32:46,149 --> 00:32:42,799
and

879
00:32:48,070 --> 00:32:46,159
you need to wait now there are many more

880
00:32:49,990 --> 00:32:48,080
galaxies filling up the universe so that

881
00:32:52,710 --> 00:32:50,000
you don't have to wait that long if you

882
00:32:55,190 --> 00:32:52,720
were to observe the entire universe so

883
00:32:56,789 --> 00:32:55,200
we are seeing a gamma ray burst every

884
00:33:00,470 --> 00:32:56,799
day simply because we are looking at

885
00:33:02,310 --> 00:33:00,480
many many galaxies at once

886
00:33:03,909 --> 00:33:02,320
the conditions necessary to make a

887
00:33:05,830 --> 00:33:03,919
gamma-ray burst

888
00:33:07,909 --> 00:33:05,840

are very special not only that you need

889
00:33:11,110 --> 00:33:07,919
to make a black hole the black hole

890
00:33:13,590 --> 00:33:11,120
needs to produce jets of material moving

891
00:33:15,509 --> 00:33:13,600
close to the speed of light and the jets

892
00:33:17,110 --> 00:33:15,519
should be able to penetrate through the

893
00:33:19,669 --> 00:33:17,120
envelope of the star

894
00:33:21,350 --> 00:33:19,679
and reach the outside world

895
00:33:22,950 --> 00:33:21,360
before they slow down

896
00:33:24,470 --> 00:33:22,960
so it's quite possible that some

897
00:33:26,389 --> 00:33:24,480
gamma-ray bursts

898
00:33:29,110 --> 00:33:26,399
do not make it

899
00:33:30,310 --> 00:33:29,120
some fail and end up in a supernova

900
00:33:32,710 --> 00:33:30,320
explosion

901
00:33:35,350 --> 00:33:32,720
we don't know in this particular case of

902
00:33:37,509 --> 00:33:35,360
a supernova whether that was the case

903
00:33:39,590 --> 00:33:37,519
or perhaps

904
00:33:41,750 --> 00:33:39,600
a neutron star formed and then material

905
00:33:44,310 --> 00:33:41,760
fell onto the neutron star to make a

906
00:33:46,230 --> 00:33:44,320
black hole it's of course possible that

907
00:33:47,029 --> 00:33:46,240
the black hole formed

908
00:33:49,110 --> 00:33:47,039
just

909
00:33:51,669 --> 00:33:49,120
at once at the beginning

910
00:33:53,669 --> 00:33:51,679
and then helped to power this very

911
00:33:55,590 --> 00:33:53,679
energetic supernova this is one of the

912
00:33:59,590 --> 00:33:55,600
brightest supernova

913
00:34:03,669 --> 00:34:01,269

great thank you uh our next question

914
00:34:07,430 --> 00:34:03,679
comes from irene klotz at the discovery

915
00:34:11,349 --> 00:34:09,109
um thank you very much i was just

916
00:34:13,829 --> 00:34:11,359
wondering of which of these two theories

917
00:34:15,909 --> 00:34:13,839
you still think is most likely um you

918
00:34:17,510 --> 00:34:15,919
laid out a really nice

919
00:34:19,909 --> 00:34:17,520
presentation for what it would mean if

920
00:34:22,310 --> 00:34:19,919
it was a really young black hole but it

921
00:34:23,829 --> 00:34:22,320
seems that that whole

922
00:34:27,349 --> 00:34:23,839
kind of line of

923
00:34:29,109 --> 00:34:27,359
of reasoning might not even be right so

924
00:34:30,950 --> 00:34:29,119
if you maybe can just

925
00:34:32,550 --> 00:34:30,960
put some context or some way of

926
00:34:34,230 --> 00:34:32,560
understanding um

927
00:34:36,950 --> 00:34:34,240
which of these two theories you think is

928
00:34:39,430 --> 00:34:36,960
more likely thanks

929
00:34:42,069 --> 00:34:39,440
um well i don't think that we can

930
00:34:44,470 --> 00:34:42,079
definitively answer that just yet

931
00:34:46,550 --> 00:34:44,480
we we have you know several years worth

932
00:34:49,349 --> 00:34:46,560
of x-ray observations but the problem is

933
00:34:51,750 --> 00:34:49,359
is that we don't have a very deep

934
00:34:53,829 --> 00:34:51,760
observation to actually look at what the

935
00:34:55,510 --> 00:34:53,839
emission from this source looks like in

936
00:34:57,190 --> 00:34:55,520
detail

937
00:34:59,829 --> 00:34:57,200
and that's what we need to do in order

938
00:35:01,190 --> 00:34:59,839

to test these theory test one theory

939
00:35:03,670 --> 00:35:01,200
against the other

940
00:35:05,270 --> 00:35:03,680
right now we can only look at the look

941
00:35:06,550 --> 00:35:05,280
at the x-ray light curve over a long

942
00:35:09,510 --> 00:35:06,560
period of time

943
00:35:11,510 --> 00:35:09,520
and look at least qualitatively at its

944
00:35:13,349 --> 00:35:11,520
x-ray spectrum over that same period of

945
00:35:15,750 --> 00:35:13,359
time

946
00:35:17,829 --> 00:35:15,760
and the shape of that spectrum

947
00:35:19,349 --> 00:35:17,839
is consistent with both an accreting

948
00:35:21,670 --> 00:35:19,359
black hole

949
00:35:24,230 --> 00:35:21,680
and also it's consistent with emission

950
00:35:26,069 --> 00:35:24,240
from a pulsar wind nebula if you look at

951
00:35:27,670 --> 00:35:26,079
it for a lot longer you would actually

952
00:35:29,910 --> 00:35:27,680
be able to distinguish between the two

953
00:35:31,910 --> 00:35:29,920
so we can't rule out one or the other at

954
00:35:34,069 --> 00:35:31,920
this point

955
00:35:36,390 --> 00:35:34,079
and if i can add them the x-ray

956
00:35:38,390 --> 00:35:36,400
luminosity has a special meaning in the

957
00:35:40,230 --> 00:35:38,400
case of a black hole it's

958
00:35:42,470 --> 00:35:40,240
the limiting luminosity that a black

959
00:35:44,790 --> 00:35:42,480
hole could have if it has a mass of

960
00:35:47,829 --> 00:35:44,800
order 5 to ten solar masses

961
00:35:50,710 --> 00:35:47,839
in the case of a pulsar wind the nebula

962
00:35:52,710 --> 00:35:50,720
you could have a variety of um

963
00:35:54,630 --> 00:35:52,720

x-ray luminosities since

964
00:35:55,910 --> 00:35:54,640
the emission there is not powered by a

965
00:35:56,829 --> 00:35:55,920
christian

966
00:36:00,710 --> 00:35:56,839
and

967
00:36:02,950 --> 00:36:00,720
so if indeed it's it's a black hole the

968
00:36:04,710 --> 00:36:02,960
the understanding of why we're seeing

969
00:36:06,710 --> 00:36:04,720
this particular luminosity is more

970
00:36:09,270 --> 00:36:06,720
straightforward

971
00:36:11,670 --> 00:36:09,280
oh and i'll add too this is kim um there

972
00:36:13,910 --> 00:36:11,680
are other supernova remnants that are

973
00:36:16,710 --> 00:36:13,920
being looked at to see if they can see

974
00:36:19,030 --> 00:36:16,720
evidence for accretion showing up and so

975
00:36:21,190 --> 00:36:19,040
far that's not been the case so we're

976
00:36:24,470 --> 00:36:21,200
seeing something here that we've not

977
00:36:25,510 --> 00:36:24,480
seen in other objects which leads me to

978
00:36:27,349 --> 00:36:25,520
favor

979
00:36:30,630 --> 00:36:27,359
just personally the black hole

980
00:36:33,589 --> 00:36:32,150
uh let me just take a quick moment to

981
00:36:35,670 --> 00:36:33,599
remind folks that uh if you're

982
00:36:37,430 --> 00:36:35,680
participating online you can find out

983
00:36:39,950 --> 00:36:37,440
more information about

984
00:36:42,550 --> 00:36:39,960
chandra and this discovery at

985
00:36:45,510 --> 00:36:42,560
www.nasa.gov forward slash chandra and

986
00:36:47,430 --> 00:36:45,520
at chandra.harvard.edu

987
00:36:50,150 --> 00:36:47,440
let me take any questions in the

988
00:36:54,550 --> 00:36:50,160

audience if there's anything further

989
00:36:56,390 --> 00:36:54,560
okay any questions by phone

990
00:36:57,829 --> 00:36:56,400
okay then with that well in today's

991
00:37:00,870 --> 00:36:57,839
media conference i'd like to thank the

992
00:37:02,950 --> 00:37:00,880
panelists for their time today um again