HUBBLE hangouts

HUBBLE 25

March 24, 2016 3pm EDT

Monster Stars in the Tarantula Nebula

1
00:00:07,639 --> 00:00:05,570
hello everyone and welcome to this

2
00:00:09,709 --> 00:00:07,649
week's Hubbell hangout my name is Tony

3
00:00:11,240 --> 00:00:09,719
Darnell and we've got another great

4
00:00:13,039 --> 00:00:11,250
hangout planned for you this week

5
00:00:15,980 --> 00:00:13,049
astronomers using the Hubble Space

6
00:00:17,689 --> 00:00:15,990
Telescope have been looking at the Large

7
00:00:20,420 --> 00:00:17,699
Magellanic Cloud and in particular the

8
00:00:23,300 --> 00:00:20,430
tarantula nebula and they have found a

9
00:00:25,099 --> 00:00:23,310
great many wonderfully large luminous

10
00:00:28,429 --> 00:00:25,109
stars that they're gonna be telling us

11
00:00:30,859 --> 00:00:28,439
about and this I don't know this one's

12
00:00:32,720 --> 00:00:30,869
this one's great we all love big things

13
00:00:34,250 --> 00:00:32,730

right well we talked about the largest

14
00:00:36,680 --> 00:00:34,260
galaxies the most massive galaxies the

15
00:00:37,880 --> 00:00:36,690
most biggest the biggest plan of the

16
00:00:40,160 --> 00:00:37,890
largest planet the most massive planet

17
00:00:42,799 --> 00:00:40,170
well here if you've ever been wondering

18
00:00:44,389 --> 00:00:42,809
about the most massive star in known in

19
00:00:45,440 --> 00:00:44,399
the universe then you're gonna want to

20
00:00:47,240 --> 00:00:45,450
stick around because we're going to talk

21
00:00:49,150 --> 00:00:47,250
a lot about that it's in these

22
00:00:52,250 --> 00:00:49,160
observations and so we're gonna

23
00:00:54,560 --> 00:00:52,260
introduce you to the most one of the

24
00:00:56,119 --> 00:00:54,570
most no it is the most massive star in

25
00:00:57,889 --> 00:00:56,129
the universe's the current record holder

26
00:01:00,560 --> 00:00:57,899
so we're gonna talk about that this week

27
00:01:03,170 --> 00:01:00,570
and a bunch of other things but before I

28
00:01:04,759 --> 00:01:03,180
introduce my guest let me oh and I

29
00:01:06,140 --> 00:01:04,769
should point out that dr. Carol

30
00:01:09,080 --> 00:01:06,150
Christian could not join us this week

31
00:01:10,880 --> 00:01:09,090
she is in gay Paree we're at a

32
00:01:14,120 --> 00:01:10,890
conference and of course as with all

33
00:01:16,670 --> 00:01:14,130
conferences Internet bandwidth is an

34
00:01:18,469 --> 00:01:16,680
issue so she is unable to join us this

35
00:01:20,480 --> 00:01:18,479
week but she'll be back next week to

36
00:01:22,190 --> 00:01:20,490
tell us hopefully what she did in Paris

37
00:01:25,789 --> 00:01:22,200
because it's an interesting place to

38
00:01:28,580 --> 00:01:25,799

visit so will with no more ado no

39
00:01:31,700 --> 00:01:28,590
further ado I'd like to introduce my

40
00:01:32,510 --> 00:01:31,710
colleague Scott Lewis hi Scott how you

41
00:01:33,920 --> 00:01:32,520
doing Tony

42
00:01:37,370 --> 00:01:33,930
good to see you again I'm glad you're

43
00:01:39,380 --> 00:01:37,380
back I just why I was here in spirit

44
00:01:42,620 --> 00:01:39,390
please you just sit there and wait until

45
00:01:45,200 --> 00:01:42,630
you I actually live in the Internet I

46
00:01:46,850 --> 00:01:45,210
just oh you know I've actually no longer

47
00:01:49,370 --> 00:01:46,860
of a physical body I just live in the

48
00:01:52,310 --> 00:01:49,380
internet it saves on rent quite a bit I

49
00:01:54,170 --> 00:01:52,320
suppose so I did so do you so you just

50
00:01:55,819 --> 00:01:54,180
sit there until from Hubble hanging out

51
00:01:57,260 --> 00:01:55,829
to Hubble hang out then I just say here

52
00:02:00,139 --> 00:01:57,270
I tweet every once in a while watch a

53
00:02:01,910 --> 00:02:00,149
lot of Netflix do you lot a Netflix on

54
00:02:03,260 --> 00:02:01,920
the internet yeah that's what I'm

55
00:02:04,850 --> 00:02:03,270
hearing it takes up a lot of space on

56
00:02:06,560 --> 00:02:04,860
the Internet these days well welcome

57
00:02:08,240 --> 00:02:06,570
back and it's good that you'll be the

58
00:02:10,100 --> 00:02:08,250
one you'll be the one that will be

59
00:02:12,680 --> 00:02:10,110
driving the internet for us which brings

60
00:02:13,420 --> 00:02:12,690
me to your questions and comments this

61
00:02:15,429 --> 00:02:13,430
is an inner

62
00:02:18,580 --> 00:02:15,439
- medium folks this is a hangout not

63
00:02:20,110 --> 00:02:18,590

only do Scott and I hang out and talk

64
00:02:22,059 --> 00:02:20,120
about science but we also do it with

65
00:02:23,170 --> 00:02:22,069
astronomers and astrophysicists all over

66
00:02:26,440 --> 00:02:23,180
the world who use the Hubble Space

67
00:02:28,660 --> 00:02:26,450
Telescope now is your chance if you want

68
00:02:30,369 --> 00:02:28,670
to ask them questions and can't leave

69
00:02:32,110 --> 00:02:30,379
comments and we hope you will do that

70
00:02:34,330 --> 00:02:32,120
and Scott's gonna tell you the best way

71
00:02:36,009 --> 00:02:34,340
to do it well that's guys absolutely so

72
00:02:37,809 --> 00:02:36,019
the the best and easiest way for us

73
00:02:39,520 --> 00:02:37,819
while we're live is actually I'm already

74
00:02:41,649 --> 00:02:39,530
seeing a bunch of other people in here

75
00:02:43,569 --> 00:02:41,659
we are using the YouTube live chat since

76
00:02:44,949 --> 00:02:43,579
this is a YouTube live event so there's

77
00:02:47,379 --> 00:02:44,959
a bunch of people so hello everyone

78
00:02:51,940 --> 00:02:47,389
and yes I am being snarky Astro girl won

79
00:02:55,869 --> 00:02:51,950
USA oh yes hello esfir girl so yes

80
00:02:57,280 --> 00:02:55,879
please continue to comment I put links

81
00:02:59,559 --> 00:02:57,290
into the press releases into the

82
00:03:01,899 --> 00:02:59,569
different files that we'll be sharing

83
00:03:03,280 --> 00:03:01,909
drink today so if you have any questions

84
00:03:04,809 --> 00:03:03,290
or comments on those or anything that

85
00:03:07,720 --> 00:03:04,819
we're discussing please let us know

86
00:03:09,490 --> 00:03:07,730
they're in live chat and as Tony said as

87
00:03:11,770 --> 00:03:09,500
well we are over on Twitter so I'm live

88
00:03:13,869 --> 00:03:11,780

tweeting this event using the hashtag

89
00:03:15,640 --> 00:03:13,879
Hubbell hangout and so if you're

90
00:03:17,409 --> 00:03:15,650
watching this after the fact you can

91
00:03:19,830 --> 00:03:17,419
leave comments on YouTube or continue

92
00:03:22,659 --> 00:03:19,840
the conversation on Twitter and we will

93
00:03:24,909 --> 00:03:22,669
be continuing that on I'll be tweeting

94
00:03:28,390 --> 00:03:24,919
as both myself and as Hubble telescope

95
00:03:30,280 --> 00:03:28,400
and we'll be really trying to focus on

96
00:03:32,559 --> 00:03:30,290
your questions and comments and and give

97
00:03:35,800 --> 00:03:32,569
you more insight into these supermassive

98
00:03:38,080 --> 00:03:35,810
stars in the trench of nebulae awesome

99
00:03:39,280 --> 00:03:38,090
okay so as I said at the top of this

100
00:03:41,589 --> 00:03:39,290
hangout we've got a really great one

101
00:03:43,360 --> 00:03:41,599
planned for you an international team of

102
00:03:45,099 --> 00:03:43,370
astronomers using the ultraviolet

103
00:03:47,949 --> 00:03:45,109
capabilities of NASA's Hubble Space

104
00:03:51,309 --> 00:03:47,959
Telescope has identified nine monster

105
00:03:54,430 --> 00:03:51,319
stars with masses over 100 times the

106
00:03:56,280 --> 00:03:54,440
mass of the Sun 100 times the mass of

107
00:03:59,319 --> 00:03:56,290
the Sun and the star cluster known as

108
00:04:02,259 --> 00:03:59,329
r136 this makes for the largest sample

109
00:04:03,879 --> 00:04:02,269
of very massive stars identified to date

110
00:04:06,009 --> 00:04:03,889
and so three of the members of that

111
00:04:08,500 --> 00:04:06,019
international team are with us now I

112
00:04:11,110 --> 00:04:08,510
have dr. Fabian Schneider he is from the

113
00:04:12,969 --> 00:04:11,120

University of Oxford as and he's an

114
00:04:15,369 --> 00:04:12,979
astrophysicist they're also joining me

115
00:04:17,890 --> 00:04:15,379
is Professor Paul Crowther he's from the

116
00:04:19,750 --> 00:04:17,900
University of Sheffield and Selma

117
00:04:21,459 --> 00:04:19,760
Dominque from the University of

118
00:04:23,709 --> 00:04:21,469
Amsterdam she's and astrophysicists

119
00:04:26,400 --> 00:04:23,719
there welcome folks but good to have you

120
00:04:29,409 --> 00:04:26,410
on our hangout I think

121
00:04:32,020 --> 00:04:29,419
okay so let's get to this so let's see I

122
00:04:34,510 --> 00:04:32,030
think I'll start with with you Fabian

123
00:04:37,510 --> 00:04:34,520
let's see the give us an ID why don't

124
00:04:41,830 --> 00:04:37,520
you start with what the observations

125
00:04:45,969 --> 00:04:41,840
were what was your purpose and looking

126
00:04:48,640 --> 00:04:45,979
at this particular star cluster well as

127
00:04:49,960 --> 00:04:48,650
you know it's far away it's a star

128
00:04:52,450 --> 00:04:49,970
cluster in the Large Magellanic Clouds

129
00:04:56,020 --> 00:04:52,460
it's let's talk about that the Large

130
00:04:58,390 --> 00:04:56,030
Magellanic Cloud is what it's enabling

131
00:05:02,170 --> 00:04:58,400
dwarf galaxies next to our Milky Way one

132
00:05:03,939 --> 00:05:02,180
of our next closest companion so to say

133
00:05:06,399 --> 00:05:03,949
so it's sort of one of those satellite

134
00:05:08,589 --> 00:05:06,409
galaxies around lutely exactly oh yeah

135
00:05:10,749 --> 00:05:08,599
but within that there's a huge star

136
00:05:12,309 --> 00:05:10,759
forming region a gigantic one probably

137
00:05:14,610 --> 00:05:12,319
the largest in the local universe at

138
00:05:18,100 --> 00:05:14,620

least largest that we can really

139
00:05:19,870 --> 00:05:18,110
dissolve into individual stars and in

140
00:05:22,059 --> 00:05:19,880
that huge star forming region which by

141
00:05:24,969 --> 00:05:22,069
the way was supposed to be a single star

142
00:05:27,219 --> 00:05:24,979
in the past hence the name $30 right so

143
00:05:29,709 --> 00:05:27,229
dourados had just a consolation in the

144
00:05:32,140 --> 00:05:29,719
south and it was a circuit thirties

145
00:05:33,879 --> 00:05:32,150
brightest in there and in that region

146
00:05:37,570 --> 00:05:33,889
you have a huge star forming crowd and

147
00:05:39,100 --> 00:05:37,580
in there another huge star cluster so

148
00:05:41,409 --> 00:05:39,110
it's really far away and the cluster

149
00:05:43,749 --> 00:05:41,419
itself is tiny so if you want to be

150
00:05:46,120 --> 00:05:43,759
solve it you're gonna go and look for

151
00:05:48,610 --> 00:05:46,130
Hubble observations or alternative

152
00:05:51,100 --> 00:05:48,620
alternatively if you have some adaptive

153
00:05:53,670 --> 00:05:51,110
optics observations from the VLT for

154
00:05:55,719 --> 00:05:53,680
example and with those you can then

155
00:05:57,969 --> 00:05:55,729
individually resolve all these massive

156
00:05:59,499 --> 00:05:57,979
beasts in there and only with these

157
00:06:03,370 --> 00:05:59,509
techniques you can see individual stars

158
00:06:06,189 --> 00:06:03,380
and see and weigh them so what Scott has

159
00:06:08,050 --> 00:06:06,199
up here is what exactly is this the star

160
00:06:10,749 --> 00:06:08,060
cluster itself down on the lower part of

161
00:06:14,260 --> 00:06:10,759
it absolutely exactly so if you look

162
00:06:16,059 --> 00:06:14,270
into that picture maybe for a moment you

163
00:06:18,640 --> 00:06:16,069

can see that all these blue dots that's

164
00:06:21,610 --> 00:06:18,650
the main star cluster we are thinking of

165
00:06:23,830 --> 00:06:21,620
and we're looking at and again this just

166
00:06:25,839 --> 00:06:23,840
this snapshot of the region is in

167
00:06:28,029 --> 00:06:25,849
principle quite huge it's not that small

168
00:06:29,800 --> 00:06:28,039
and we've been only looking into the

169
00:06:31,450 --> 00:06:29,810
very heart of this cluster so if you see

170
00:06:34,570 --> 00:06:31,460
this over dense region this over dense

171
00:06:36,639 --> 00:06:34,580
blue region somewhat in the mid well in

172
00:06:38,610 --> 00:06:36,649
the lower middle that's exactly where

173
00:06:40,110 --> 00:06:38,620
we've been pointing Hubble at

174
00:06:43,860 --> 00:06:40,120
and then we've been looking into the UV

175
00:06:46,890 --> 00:06:43,870
in at least that paper now and we have

176
00:06:48,450 --> 00:06:46,900
more more data coming up soon and trying

177
00:06:50,370 --> 00:06:48,460
to figure out which objects are there

178
00:06:52,830 --> 00:06:50,380
and in fact what they are I mean no one

179
00:06:55,770 --> 00:06:52,840
knew that before at least partly

180
00:06:58,350 --> 00:06:55,780
so you said before before the era of

181
00:07:01,020 --> 00:06:58,360
large telescope space telescopes this

182
00:07:03,510 --> 00:07:01,030
was really so small and unresolved that

183
00:07:05,340 --> 00:07:03,520
people thought it was just one star for

184
00:07:07,050 --> 00:07:05,350
the longest times I right it's

185
00:07:09,030 --> 00:07:07,060
absolutely right and there's another fun

186
00:07:10,680 --> 00:07:09,040
story about that one okay the past

187
00:07:12,570 --> 00:07:10,690
people have been thinking well this is

188
00:07:14,460 --> 00:07:12,580

one star but it's not every what we know

189
00:07:17,010 --> 00:07:14,470
now it's issue a whole star cluster and

190
00:07:21,029 --> 00:07:17,020
then people try to assign one single

191
00:07:23,070 --> 00:07:21,039
mass to this app and star in in in the

192
00:07:25,710 --> 00:07:23,080
region and they came up with the mass of

193
00:07:29,400 --> 00:07:25,720
several times thousands of yeah or that

194
00:07:31,170 --> 00:07:29,410
of a son for a son so it was huge in the

195
00:07:33,629 --> 00:07:31,180
past but then people were able to evolve

196
00:07:35,909 --> 00:07:33,639
it with interferometry and now we're

197
00:07:37,830 --> 00:07:35,919
able to look into it with Hubble and see

198
00:07:39,689 --> 00:07:37,840
its many many many objects but still

199
00:07:41,460 --> 00:07:39,699
it's a thing for fun part of the whole

200
00:07:44,640 --> 00:07:41,470
story you still have the most massive

201
00:07:46,290 --> 00:07:44,650
beast sitting in that cluster no well

202
00:07:52,770 --> 00:07:46,300
that's let's get to that also this is a

203
00:07:54,600 --> 00:07:52,780
this is the Paul this is the as as

204
00:07:57,089 --> 00:07:54,610
Fabien was pointing out the largest

205
00:07:58,800 --> 00:07:57,099
galaxy or the this has some pretty large

206
00:08:01,050 --> 00:07:58,810
stars and can you give us some idea of

207
00:08:04,320 --> 00:08:01,060
the kinds of stars that are in the star

208
00:08:06,690 --> 00:08:04,330
cluster so it's a very rich star cluster

209
00:08:08,520 --> 00:08:06,700
it's probably got at least 50,000 or

210
00:08:10,710 --> 00:08:08,530
maybe a hundred thousand stars in there

211
00:08:12,900 --> 00:08:10,720
but the things that we the thing is that

212
00:08:15,060 --> 00:08:12,910
we can see in that image it does blue

213
00:08:17,010 --> 00:08:15,070

glowing white points of light and that

214
00:08:18,870 --> 00:08:17,020
in that kind of concentrated core of

215
00:08:20,719 --> 00:08:18,880
that cluster the cluster itself is only

216
00:08:23,879 --> 00:08:20,729
a few light-years across

217
00:08:27,420 --> 00:08:23,889
but it's already got you know maybe

218
00:08:29,070 --> 00:08:27,430
50,000 or 100,000 stars within it it's a

219
00:08:30,930 --> 00:08:29,080
bit like an iceberg you know the things

220
00:08:32,159 --> 00:08:30,940
we see just the tip of the iceberg the

221
00:08:34,709 --> 00:08:32,169
things we should dominating the light

222
00:08:37,260 --> 00:08:34,719
it's the most massive stars which give

223
00:08:39,449 --> 00:08:37,270
off the most radiation and this is like

224
00:08:42,329 --> 00:08:39,459
this is a Hubble wide field three

225
00:08:45,690 --> 00:08:42,339
composite image of this central region

226
00:08:48,660 --> 00:08:45,700
of the 32 Ardis region within the Large

227
00:08:50,310 --> 00:08:48,670
Magellanic Cloud so it's a the way I

228
00:08:51,690 --> 00:08:50,320
like to kind of picture it is it the

229
00:08:54,210 --> 00:08:51,700
whole magic

230
00:08:57,150 --> 00:08:54,220
the whole tarantula nebula on the sky

231
00:08:59,190 --> 00:08:57,160
spans about the same angular extent of

232
00:09:01,350 --> 00:08:59,200
the Orion Nebula in our own Milky Way

233
00:09:03,510 --> 00:09:01,360
it's a hunt it's a hundred times further

234
00:09:07,110 --> 00:09:03,520
away so it's actually a hundred times

235
00:09:08,490 --> 00:09:07,120
bigger than the Orion Nebula so there's

236
00:09:09,570 --> 00:09:08,500
probably a couple hundred thousand stars

237
00:09:11,610 --> 00:09:09,580
in the entire nebula

238
00:09:15,170 --> 00:09:11,620

and maybe fifty thousand within that

239
00:09:17,820 --> 00:09:15,180
central few parsec a few light-years

240
00:09:21,210 --> 00:09:17,830
within within our 1:36 itself and our

241
00:09:22,530 --> 00:09:21,220
3:6 was once thought to be a star and

242
00:09:26,910 --> 00:09:22,540
then it was resolved into three

243
00:09:28,890 --> 00:09:26,920
components a B and C and and then later

244
00:09:30,930 --> 00:09:28,900
on it was in broken-down the component a

245
00:09:32,490 --> 00:09:30,940
which is the cluster itself has been

246
00:09:34,740 --> 00:09:32,500
broken down initially into an eight

247
00:09:37,350 --> 00:09:34,750
components and in fact we now know of

248
00:09:40,710 --> 00:09:37,360
many many stars in there and these the

249
00:09:42,180 --> 00:09:40,720
most massive stars the ones which which

250
00:09:44,010 --> 00:09:42,190
we were basically observing in

251
00:09:47,940 --> 00:09:44,020
ultraviolet we looked at we found

252
00:09:50,730 --> 00:09:47,950
several dozen stars with masses of at

253
00:09:53,160 --> 00:09:50,740
least 50 times the mass of the Sun so

254
00:09:57,030 --> 00:09:53,170
these are the kind of very very luminous

255
00:09:58,740 --> 00:09:57,040
may be each of them emitting maybe a

256
00:10:00,420 --> 00:09:58,750
hundred thousand five hundred thousand

257
00:10:02,580 --> 00:10:00,430
or sometimes a million times more than

258
00:10:04,770 --> 00:10:02,590
the Sun these are extremely hot and very

259
00:10:06,900 --> 00:10:04,780
blue stars and that's why they look kind

260
00:10:08,550 --> 00:10:06,910
of bluey white in that picture okay I

261
00:10:11,220 --> 00:10:08,560
want to get more in depth into the stars

262
00:10:12,990 --> 00:10:11,230
themselves in just a minute but someone

263
00:10:15,840 --> 00:10:13,000

can you help me get some idea of the

264
00:10:17,340 --> 00:10:15,850
topology what this image shows a lot

265
00:10:19,200 --> 00:10:17,350
more than just the star cluster is the

266
00:10:22,710 --> 00:10:19,210
entire thing that we're looking at here

267
00:10:25,170 --> 00:10:22,720
the Scott has up is all of this star

268
00:10:27,150 --> 00:10:25,180
forming region the the gas and the the

269
00:10:29,850 --> 00:10:27,160
other of the dust and everything else

270
00:10:31,740 --> 00:10:29,860
all around it what help me understand

271
00:10:34,140 --> 00:10:31,750
this topology here I know what the

272
00:10:36,390 --> 00:10:34,150
cluster is like see that but it is also

273
00:10:38,430 --> 00:10:36,400
these blue stars you know just a little

274
00:10:41,100 --> 00:10:38,440
bit higher up are they part of the same

275
00:10:44,070 --> 00:10:41,110
cluster and then what role do these if

276
00:10:45,900 --> 00:10:44,080
any of these clouds play so these clouds

277
00:10:48,510 --> 00:10:45,910
are where we think stars are being

278
00:10:51,210 --> 00:10:48,520
formed so before this cluster that was

279
00:10:52,860 --> 00:10:51,220
was here there were only clouds it would

280
00:10:55,230 --> 00:10:52,870
be a little hard to see them now we see

281
00:10:56,760 --> 00:10:55,240
them because they're heated up by the by

282
00:10:59,550 --> 00:10:56,770
the stars around them they shape them

283
00:11:03,090 --> 00:10:59,560
you cannot see it too well but the stars

284
00:11:04,800 --> 00:11:03,100
they shine with such strong radiation

285
00:11:05,160 --> 00:11:04,810
that they actually shape it into the

286
00:11:07,829 --> 00:11:05,170
form

287
00:11:10,050 --> 00:11:07,839
fingers and filaments so on the top for

288
00:11:13,470 --> 00:11:10,060

example you see some of the structures

289
00:11:15,150 --> 00:11:13,480
in these clouds it looks like smoke but

290
00:11:18,810 --> 00:11:15,160
it's actually there's new stars being

291
00:11:20,550 --> 00:11:18,820
formed in that region and so as soon as

292
00:11:24,210 --> 00:11:20,560
the stars become so hot that they can

293
00:11:25,860 --> 00:11:24,220
blow off these gas clouds nearby that's

294
00:11:28,259 --> 00:11:25,870
the part where we start to see them so

295
00:11:29,819 --> 00:11:28,269
the blue stars in the very middle you

296
00:11:32,340 --> 00:11:29,829
see they have cleared out most of the

297
00:11:33,569 --> 00:11:32,350
area around them they might be part of

298
00:11:35,189 --> 00:11:33,579
the star cluster and you see outer

299
00:11:37,259 --> 00:11:35,199
layers they may be part of the

300
00:11:39,360 --> 00:11:37,269
surroundings it's a little hard to tell

301
00:11:41,670 --> 00:11:39,370
we know that the star cluster is also

302
00:11:44,220 --> 00:11:41,680
shooting out stars into the environment

303
00:11:46,740 --> 00:11:44,230
so stars do not stay in the same place

304
00:11:49,710 --> 00:11:46,750
when they live their lives so so this is

305
00:11:52,740 --> 00:11:49,720
really active if we could magically

306
00:11:56,280 --> 00:11:52,750
somehow put a camera let's say off to 90

307
00:11:59,189 --> 00:11:56,290
degrees of this nebula would we see kind

308
00:12:00,900 --> 00:11:59,199
of a cave or a blown-out region where

309
00:12:02,490 --> 00:12:00,910
this is kind of a bowl because remember

310
00:12:03,870 --> 00:12:02,500
when we did those we've seen those fly

311
00:12:05,100 --> 00:12:03,880
throughs at least the ones that Frank

312
00:12:08,009 --> 00:12:05,110
summers have made with the Hubble stuff

313
00:12:10,470 --> 00:12:08,019

on the m42 the Orion Nebula we've seen

314
00:12:12,630 --> 00:12:10,480
these sort of blown out bowl of the

315
00:12:13,769 --> 00:12:12,640
Orion Nebula where the stars have formed

316
00:12:16,949 --> 00:12:13,779
employment where we see something like

317
00:12:20,939 --> 00:12:16,959
that maybe here's a one big twisties I

318
00:12:22,470 --> 00:12:20,949
would say okay well compared to the

319
00:12:24,180 --> 00:12:22,480
Orion Nebula and I know that Paul you

320
00:12:25,620 --> 00:12:24,190
alluded to this and and I think I might

321
00:12:27,810 --> 00:12:25,630
have gotten distracted when you said the

322
00:12:30,540 --> 00:12:27,820
difference but how does this region and

323
00:12:33,000 --> 00:12:30,550
this nebula compare with the Orion

324
00:12:35,430 --> 00:12:33,010
Nebula you said it's much much larger is

325
00:12:37,259 --> 00:12:35,440
that right yeah the whole region is

326
00:12:38,910 --> 00:12:37,269
around a hundred times bigger it's it's

327
00:12:40,889 --> 00:12:38,920
about the same angular size bigger okay

328
00:12:42,960 --> 00:12:40,899
yeah hundred times bigger this is

329
00:12:46,740 --> 00:12:42,970
probably a central part of the tarantula

330
00:12:48,840 --> 00:12:46,750
so it's a central half or so or third of

331
00:12:51,240 --> 00:12:48,850
the whole tarantula nebula so it's about

332
00:12:53,699 --> 00:12:51,250
overall 20 was around the 100 times

333
00:12:57,120 --> 00:12:53,709
bigger with a hundred times more stars

334
00:12:59,280 --> 00:12:57,130
than your eye nebula and it's also about

335
00:13:01,410 --> 00:12:59,290
a thousand times brighter the Kista star

336
00:13:03,150 --> 00:13:01,420
as a minute some of the stars are much

337
00:13:04,500 --> 00:13:03,160
hotter than those in your mind negative

338
00:13:06,629 --> 00:13:04,510

so if you put them two at the same

339
00:13:09,030 --> 00:13:06,639
distance you know it would be a thousand

340
00:13:10,769 --> 00:13:09,040
times brighter and it would be a hundred

341
00:13:12,540 --> 00:13:10,779
times larger on the sky if we put a

342
00:13:15,030 --> 00:13:12,550
distance of the Orion Nebula which was

343
00:13:17,260 --> 00:13:15,040
only you know five hundred parsec away

344
00:13:20,170 --> 00:13:17,270
one and a half thousand light-years

345
00:13:21,970 --> 00:13:20,180
much much richer staffing region but

346
00:13:23,890 --> 00:13:21,980
it's I'll guess it's comparisons more

347
00:13:26,380 --> 00:13:23,900
with the Orion molecular cloud from

348
00:13:29,050 --> 00:13:26,390
which the stars are form that's a much

349
00:13:31,530 --> 00:13:29,060
larger region around the nebula that we

350
00:13:34,060 --> 00:13:31,540
can that the famous nebula there's much

351
00:13:35,320 --> 00:13:34,070
extending well past the constellation

352
00:13:36,700 --> 00:13:35,330
boundaries itself now the reason we're

353
00:13:38,890 --> 00:13:36,710
talking about this folks is that the

354
00:13:40,960 --> 00:13:38,900
Orion Nebula is a star forming region

355
00:13:42,400 --> 00:13:40,970
within our own galaxy and so there's a

356
00:13:44,560 --> 00:13:42,410
lot of stars going on there

357
00:13:46,810 --> 00:13:44,570
all of our BR being born there but as

358
00:13:48,580 --> 00:13:46,820
polish's pointing out the kinds of stars

359
00:13:50,500 --> 00:13:48,590
and just a magnitude of the whole thing

360
00:13:52,870 --> 00:13:50,510
it's much much greater in the large

361
00:13:55,750 --> 00:13:52,880
magellanic cloud so you said earlier

362
00:13:57,790 --> 00:13:55,760
that there was different components to

363
00:13:59,530 --> 00:13:57,800

this it was a and a B component was that

364
00:14:01,630 --> 00:13:59,540
just because telescopes got better at

365
00:14:05,740 --> 00:14:01,640
resolving this area and we could see it

366
00:14:09,100 --> 00:14:05,750
more for what it was or yes around about

367
00:14:11,380 --> 00:14:09,110
60 years ago that it was first

368
00:14:14,190 --> 00:14:11,390
identified as a a bright star within

369
00:14:17,080 --> 00:14:14,200
that within the Large Magellanic Cloud

370
00:14:19,120 --> 00:14:17,090
with one three six and then it was in

371
00:14:21,040 --> 00:14:19,130
the 80s where it was then resolved into

372
00:14:23,170 --> 00:14:21,050
three components a B C and then

373
00:14:26,440 --> 00:14:23,180
component a it turned out to be the

374
00:14:29,200 --> 00:14:26,450
cluster was then in the mid eighties we

375
00:14:31,180 --> 00:14:29,210
thought into a number of components but

376
00:14:32,680 --> 00:14:31,190
really if you could see if you could

377
00:14:34,870 --> 00:14:32,690
resolve all the stars you would find

378
00:14:36,910 --> 00:14:34,880
many many tens of thousands of

379
00:14:38,470 --> 00:14:36,920
components in there it's just the right

380
00:14:42,100 --> 00:14:38,480
ones and ones that shine the brightest

381
00:14:44,530 --> 00:14:42,110
they're easy easy to see okay well so

382
00:14:47,050 --> 00:14:44,540
astro girl one USA hello welcome back

383
00:14:48,250 --> 00:14:47,060
I'm glad to see you're back again I was

384
00:14:50,920 --> 00:14:48,260
asking a relevant question what we're

385
00:14:53,350 --> 00:14:50,930
talking about how bright is it now I

386
00:14:55,480 --> 00:14:53,360
assume by that she saw my the magnitude

387
00:14:57,340 --> 00:14:55,490
let's pretend that it's just the one

388
00:14:59,740 --> 00:14:57,350

star thirty-two Radice or whatever and

389
00:15:02,020 --> 00:14:59,750
what would be the brightness of this

390
00:15:03,730 --> 00:15:02,030
thing and maybe is a beam is there

391
00:15:06,970 --> 00:15:03,740
something you can answer for us yeah

392
00:15:09,550 --> 00:15:06,980
sure so individually if you if it

393
00:15:11,320 --> 00:15:09,560
speaking of one of the most brightest

394
00:15:13,930 --> 00:15:11,330
most massive objects in there it can

395
00:15:15,520 --> 00:15:13,940
easily be millions or the luminosity of

396
00:15:18,610 --> 00:15:15,530
this object can be 1 million times that

397
00:15:20,410 --> 00:15:18,620
of our Sun and even above that so it's

398
00:15:23,440 --> 00:15:20,420
one individual object and now you can

399
00:15:26,470 --> 00:15:23,450
count well we have plenty of them say 50

400
00:15:29,770 --> 00:15:26,480
all of that at all of magnitude so the

401
00:15:30,490 --> 00:15:29,780
whole cluster itself can go up to 12 10

402
00:15:34,720 --> 00:15:30,500
to the 7

403
00:15:38,140 --> 00:15:34,730
solar luminosities so it's really you

404
00:15:39,460 --> 00:15:38,150
seven zeroes behind it and it's you know

405
00:15:42,820 --> 00:15:39,470
city you get can get from the cluster

406
00:15:44,830 --> 00:15:42,830
itself yeah okay so the way I and also

407
00:15:46,360 --> 00:15:44,840
interpret this is if I'm an old amateur

408
00:15:52,750 --> 00:15:46,370
astronomer and let me just get rid of

409
00:15:56,350 --> 00:15:52,760
that I'm an amateur astronomer and okay

410
00:15:58,780 --> 00:15:56,360
yeah and if I wanted to look at this

411
00:15:59,860 --> 00:15:58,790
through a telescope from my backyard

412
00:16:10,990 --> 00:15:59,870
could I

413
00:16:13,210 --> 00:16:11,000

or is it to dim the look all day and

414
00:16:15,490 --> 00:16:13,220
night long Tony but unless I can see

415
00:16:20,290 --> 00:16:15,500
through the earth I'm so glad you're

416
00:16:22,360 --> 00:16:20,300
here Scott right so if I were it like

417
00:16:24,700 --> 00:16:22,370
let's say I'm in Chile but I'm not up in

418
00:16:26,590 --> 00:16:24,710
the Andes and I want to look at this

419
00:16:28,660 --> 00:16:26,600
could I yeah what I'd be able to see in

420
00:16:30,610 --> 00:16:28,670
an amateur scope oh you would even see

421
00:16:32,320 --> 00:16:30,620
it with a bear I yeah that's the source

422
00:16:33,550 --> 00:16:32,330
that bright good that's that's sort of

423
00:16:36,910 --> 00:16:33,560
where I was going with that thank you

424
00:16:38,410 --> 00:16:36,920
Scott for making me uh well didn't come

425
00:16:40,450 --> 00:16:38,420
in the whole thing I'm just I'm just

426
00:16:41,940 --> 00:16:40,460
saying yeah I know I let you let that go

427
00:16:45,370 --> 00:16:41,950
so I should be counting my blessed

428
00:16:48,970 --> 00:16:45,380
okay so let's not really lesser in this

429
00:16:54,720 --> 00:16:48,980
group I got a comment here from Paul

430
00:16:57,460 --> 00:16:54,730
from astronomy in Jake Ombuds

431
00:16:59,860 --> 00:16:57,470
themselves in the galaxy cluster or in

432
00:17:01,360 --> 00:16:59,870
the star cluster and as we've you've

433
00:17:03,520 --> 00:17:01,370
already pointed out they're extremely

434
00:17:05,650 --> 00:17:03,530
bright they're they're much much larger

435
00:17:07,780 --> 00:17:05,660
or much more massive than the Sun in

436
00:17:12,460 --> 00:17:07,790
just about every single way they're all

437
00:17:14,170 --> 00:17:12,470
very blue which means give us an idea

438
00:17:16,660 --> 00:17:14,180

about first of all I want to know why

439
00:17:18,160 --> 00:17:16,670
they're blue and I know then that you're

440
00:17:20,140 --> 00:17:18,170
gonna tell me why the Hubble Space

441
00:17:22,210 --> 00:17:20,150
Telescope was able to get such clear

442
00:17:24,280 --> 00:17:22,220
pictures of this and maybe can you give

443
00:17:26,520 --> 00:17:24,290
us a sort of a quick quick rundown on

444
00:17:29,320 --> 00:17:26,530
why these stars are blue and and

445
00:17:32,680 --> 00:17:29,330
basically the the classification of

446
00:17:34,990 --> 00:17:32,690
stars that are in this mmm so I think

447
00:17:37,510 --> 00:17:35,000
the easiest way to explain that is by

448
00:17:39,190 --> 00:17:37,520
looking at a normal flame so if you if

449
00:17:41,080 --> 00:17:39,200
you look at a flame where this hottest

450
00:17:42,580 --> 00:17:41,090
it looks as if it was balloon right and

451
00:17:44,390 --> 00:17:42,590
then the flame gets maybe a bit cooler

452
00:17:45,710 --> 00:17:44,400
to the outside and it's getting

453
00:17:48,320 --> 00:17:45,720
I gather and together and maybe orange

454
00:17:50,510 --> 00:17:48,330
maybe some yellow inside and the star is

455
00:17:52,370 --> 00:17:50,520
nothing but like a flame in principle

456
00:17:54,440 --> 00:17:52,380
it's a blackbody as we would call it and

457
00:17:57,110 --> 00:17:54,450
so it's temperature on the surface tells

458
00:17:58,490 --> 00:17:57,120
what colored will have and these objects

459
00:18:00,350 --> 00:17:58,500
are very massive meaning they're

460
00:18:03,650 --> 00:18:00,360
extremely hot so on the surfaces we

461
00:18:07,130 --> 00:18:03,660
speak of say 50 thousand Kelvin or 50

462
00:18:08,510 --> 00:18:07,140
thousand degrees Celsius and that's its

463
00:18:09,080 --> 00:18:08,520

temperature and if you convert it into

464
00:18:11,660 --> 00:18:09,090
colors

465
00:18:13,820 --> 00:18:11,670
it is blue or in fact these objects

466
00:18:15,470 --> 00:18:13,830
would peak in the ultraviolet which we

467
00:18:17,900 --> 00:18:15,480
fortunately can't see and which you

468
00:18:24,830 --> 00:18:17,910
wouldn't see on earth our atmosphere is

469
00:18:26,570 --> 00:18:24,840
luckily and healthy right yep and so for

470
00:18:28,220 --> 00:18:26,580
us they look blue but if you really look

471
00:18:30,020 --> 00:18:28,230
at where they have their maximum in

472
00:18:32,630 --> 00:18:30,030
radiation it's somewhere over elephant

473
00:18:34,570 --> 00:18:32,640
now as carol has pointed out and if she

474
00:18:36,950 --> 00:18:34,580
were here I'm sure would do so again

475
00:18:39,140 --> 00:18:36,960
really Space Telescope's I think it was

476
00:18:42,670 --> 00:18:39,150
you Paul that pointed out that the ELT

477
00:18:45,710 --> 00:18:42,680
the extremely large telescope run by ESO

478
00:18:47,450 --> 00:18:45,720
the European Southern Observatory would

479
00:18:49,400 --> 00:18:47,460
be able to resolve the stars but not

480
00:18:51,890 --> 00:18:49,410
necessary I wouldn't be able to see this

481
00:18:55,610 --> 00:18:51,900
in the UV because it's a ground-based

482
00:18:58,340 --> 00:18:55,620
telescope so Hubble is one is the only

483
00:19:00,290 --> 00:18:58,350
game in town I'm told by Carol that if

484
00:19:02,600 --> 00:19:00,300
you want to get UV observations you have

485
00:19:05,120 --> 00:19:02,610
to go to Hubble and describe for me a

486
00:19:07,420 --> 00:19:05,130
little bit of Fabien how with what

487
00:19:09,980 --> 00:19:07,430
instrument you got these observations

488
00:19:12,260 --> 00:19:09,990

all right I'll try to explain that I

489
00:19:14,210 --> 00:19:12,270
guess Paul is the expert is all fair ok

490
00:19:15,680 --> 00:19:14,220
well then let me it's no problem I can

491
00:19:17,630 --> 00:19:15,690
you can start and you can kick in yeah

492
00:19:20,150 --> 00:19:17,640
you have to do this I'm asking home

493
00:19:21,650 --> 00:19:20,160
person you guys say now give that one a

494
00:19:23,900 --> 00:19:21,660
call

495
00:19:27,160 --> 00:19:23,910
well the instrument itself is quotes dis

496
00:19:30,080 --> 00:19:27,170
which is when Hubble it's in there in

497
00:19:31,550 --> 00:19:30,090
interferometer and so a spectrograph and

498
00:19:34,340 --> 00:19:31,560
what you do with that is you just have

499
00:19:36,350 --> 00:19:34,350
slits on the sky and in each slit you

500
00:19:38,510 --> 00:19:36,360
take a spectrograph of all the objects

501
00:19:40,250 --> 00:19:38,520
so we oriented all those slits on to the

502
00:19:43,040 --> 00:19:40,260
sky such that in each slit we would have

503
00:19:46,340 --> 00:19:43,050
a couple of stars and then took Hubble

504
00:19:48,260 --> 00:19:46,350
to get all their spectra and that's yeah

505
00:19:49,730 --> 00:19:48,270
what we can get from that and then of

506
00:19:51,620 --> 00:19:49,740
course with a spectrograph or with the

507
00:19:53,480 --> 00:19:51,630
spectrum of the star you have a lot of

508
00:19:56,240 --> 00:19:53,490
information available in particular from

509
00:19:58,280 --> 00:19:56,250
the UV range it's telling a lot of about

510
00:19:59,870 --> 00:19:58,290
the details of the objects

511
00:20:02,000 --> 00:19:59,880
for example what kind of winds they have

512
00:20:04,820 --> 00:20:02,010
how fast the wind is escaping from the

513
00:20:07,370 --> 00:20:04,830

surfaces and so on and so forth okay so

514
00:20:09,980 --> 00:20:07,380
the so by the way still stands for the

515
00:20:12,530 --> 00:20:09,990
Space Telescope imaging spectrograph and

516
00:20:14,240 --> 00:20:12,540
it takes images and spectra at the same

517
00:20:16,430 --> 00:20:14,250
time and of course the Hubble has

518
00:20:18,560 --> 00:20:16,440
ultraviolet filters onboard that lets

519
00:20:21,170 --> 00:20:18,570
you see in these wavelengths so a Selma

520
00:20:23,780 --> 00:20:21,180
I know so we've talked about the colors

521
00:20:25,370 --> 00:20:23,790
of these stars and Polly's told us about

522
00:20:27,890 --> 00:20:25,380
how large they are things like that I

523
00:20:29,990 --> 00:20:27,900
want to know and I I want to know first

524
00:20:34,030 --> 00:20:30,000
of all how how do they get this big it

525
00:20:37,370 --> 00:20:34,040
what's so special about this about this

526
00:20:39,770 --> 00:20:37,380
cluster that makes such enormous stars I

527
00:20:42,320 --> 00:20:39,780
mean is there anything how they get this

528
00:20:44,270 --> 00:20:42,330
way oh you're asking the right question

529
00:20:48,050 --> 00:20:44,280
this is the question this is the big

530
00:20:49,490 --> 00:20:48,060
question for big box yeah it's the

531
00:20:51,410 --> 00:20:49,500
question we don't know the answer to and

532
00:20:53,360 --> 00:20:51,420
that's why we're so well excited to find

533
00:20:55,040 --> 00:20:53,370
them it's a it's frightening for for a

534
00:20:57,140 --> 00:20:55,050
theorist we don't know how such massive

535
00:20:59,420 --> 00:20:57,150
stars form because when you're forming

536
00:21:01,310 --> 00:20:59,430
them they are already so hot that they

537
00:21:03,380 --> 00:21:01,320
they already start to radiate before you

538
00:21:06,410 --> 00:21:03,390

before they have grown so massive and so

539
00:21:08,660 --> 00:21:06,420
all theoretical models that are trying

540
00:21:11,900 --> 00:21:08,670
to explain how you can make such massive

541
00:21:13,580 --> 00:21:11,910
stars they're failing so it's extremely

542
00:21:16,670 --> 00:21:13,590
interesting problem if you're in a

543
00:21:18,500 --> 00:21:16,680
theoretical astrophysicist Paul Crowther

544
00:21:20,120 --> 00:21:18,510
takes the observations there there we

545
00:21:21,500 --> 00:21:20,130
better try to understand when you see em

546
00:21:22,790 --> 00:21:21,510
you know they're there but so you're

547
00:21:26,150 --> 00:21:22,800
saying we've also you know on astronomy

548
00:21:27,710 --> 00:21:26,160
101 we've learned if you take if you go

549
00:21:31,040 --> 00:21:27,720
to university and you take your first

550
00:21:34,490 --> 00:21:31,050
class in stellar evolution you will take

551
00:21:36,230 --> 00:21:34,500
a very easy calculation and you will

552
00:21:38,150 --> 00:21:36,240
calculate yourself that is impossible to

553
00:21:41,510 --> 00:21:38,160
make any star above about 100 solar

554
00:21:43,310 --> 00:21:41,520
masses and then cool Crowther comes

555
00:21:44,930 --> 00:21:43,320
along and tells us well I have all these

556
00:21:46,340 --> 00:21:44,940
stars that are hundred fifty two hundred

557
00:21:49,070 --> 00:21:46,350
and Amy tells us they're born with

558
00:21:51,740 --> 00:21:49,080
around 300 so it's it's it's really

559
00:21:53,750 --> 00:21:51,750
turning a lot of our field around they

560
00:21:56,000 --> 00:21:53,760
don't get that way later they're born at

561
00:21:58,070 --> 00:21:56,010
this eyes okay so it turns out that that

562
00:21:59,420 --> 00:21:58,080
that simple exercise we do in the first

563
00:22:01,220 --> 00:21:59,430

year when you come to the University was

564
00:22:02,480 --> 00:22:01,230
a little bit simplified and so if you

565
00:22:04,280 --> 00:22:02,490
think about the details it's not

566
00:22:07,160 --> 00:22:04,290
impossible that there would be stars

567
00:22:09,380 --> 00:22:07,170
existing that are so massive but still

568
00:22:11,899 --> 00:22:09,390
we have no idea how so much gas can

569
00:22:13,489 --> 00:22:11,909
actually collect and make such a star

570
00:22:15,859 --> 00:22:13,499
and so we're trying to think of creative

571
00:22:17,599 --> 00:22:15,869
ways to find them and so one of the

572
00:22:19,819 --> 00:22:17,609
things you see we apparently find them

573
00:22:23,119 --> 00:22:19,829
only in very dense cluster like this and

574
00:22:25,519 --> 00:22:23,129
so one of the ideas that also Fabian and

575
00:22:27,499 --> 00:22:25,529
we have worked on is maybe these stars

576
00:22:29,659 --> 00:22:27,509
are not formed as normal stars but you

577
00:22:31,819 --> 00:22:29,669
can make them when you smash more than

578
00:22:34,729 --> 00:22:31,829
one star into each other so you make

579
00:22:36,769 --> 00:22:34,739
stars that are also massive but not

580
00:22:39,199 --> 00:22:36,779
crazy massive and you maybe make them in

581
00:22:41,029 --> 00:22:39,209
pairs and these pairs later come

582
00:22:45,649 --> 00:22:41,039
together we have an animation that shows

583
00:22:48,979 --> 00:22:45,659
some of this stuff so here we go okay so

584
00:22:52,399 --> 00:22:48,989
described here what what we're seeing so

585
00:22:54,979 --> 00:22:52,409
this is an animation of a star we found

586
00:22:57,049 --> 00:22:54,989
somewhere else in the region and this is

587
00:22:58,879 --> 00:22:57,059
what we call a contact binary is a kind

588
00:23:00,729 --> 00:22:58,889

of a peanut-shaped binary it's two stars

589
00:23:03,349 --> 00:23:00,739
that are actually touching each other

590
00:23:06,079 --> 00:23:03,359
in the kissing yes that's the press

591
00:23:08,989 --> 00:23:06,089
release we had a a few months ago

592
00:23:10,909 --> 00:23:08,999
actually it's not in this cluster but

593
00:23:11,359 --> 00:23:10,919
these two stars are 30 and 30 solar

594
00:23:14,089 --> 00:23:11,369
masses

595
00:23:16,639 --> 00:23:14,099
and we we think they will come together

596
00:23:18,859 --> 00:23:16,649
and make a 60 solar mass star but from

597
00:23:21,499 --> 00:23:18,869
60 is still a long way to make a 200

598
00:23:22,999 --> 00:23:21,509
solar mass star but this might be one of

599
00:23:24,649 --> 00:23:23,009
the ways we can make at least some of

600
00:23:26,079 --> 00:23:24,659
them but it's still a big puzzle it's

601
00:23:28,009 --> 00:23:26,089
not it's not

602
00:23:30,769 --> 00:23:28,019
astronomers are not agreeing that this

603
00:23:32,569 --> 00:23:30,779
is the only way to do it so Lester you

604
00:23:34,639 --> 00:23:32,579
might even merge these ones and and

605
00:23:38,269 --> 00:23:34,649
throw a third star in that passes by too

606
00:23:40,399 --> 00:23:38,279
close and they will eat up be is a real

607
00:23:41,509 --> 00:23:40,409
mess because if you take two of these

608
00:23:43,939 --> 00:23:41,519
things and they have over time

609
00:23:46,430 --> 00:23:43,949
eventually coalesce you've got two star

610
00:23:49,189 --> 00:23:46,440
cores you've got two stellar atmospheres

611
00:23:52,999 --> 00:23:49,199
all coming together to make one large

612
00:23:54,589 --> 00:23:53,009
star I just wow that just I don't even

613
00:23:58,909 --> 00:23:54,599

know what that would you know that would

614
00:24:00,619 --> 00:23:58,919
be a mess what sort of time scales are

615
00:24:03,379 --> 00:24:00,629
we talking about if this were what's

616
00:24:05,719 --> 00:24:03,389
happening how long do you think that

617
00:24:07,609 --> 00:24:05,729
would take so the whole cluster is still

618
00:24:09,680 --> 00:24:07,619
super young in astronomical terms

619
00:24:12,319 --> 00:24:09,690
meaning it's about 1 million years old

620
00:24:13,939 --> 00:24:12,329
that that is extremely young for a for a

621
00:24:15,949 --> 00:24:13,949
star cluster we don't have a many

622
00:24:17,779 --> 00:24:15,959
regions that are that young and so if

623
00:24:20,749 --> 00:24:17,789
stars pass too close if they're getting

624
00:24:23,329 --> 00:24:20,759
this close it will maybe take 10,000

625
00:24:25,430 --> 00:24:23,339
years or so or less if they if they're

626
00:24:25,789 --> 00:24:25,440
deeper in contact it can just take a few

627
00:24:27,859 --> 00:24:25,799
days

628
00:24:30,229 --> 00:24:27,869
to really do the last bit of the merger

629
00:24:32,570 --> 00:24:30,239
okay so this can happen on relatively

630
00:24:33,979 --> 00:24:32,580
short timescales so they get so let's

631
00:24:36,499 --> 00:24:33,989
get to a couple of these questions then

632
00:24:37,700 --> 00:24:36,509
that a word that I'm saying let's get to

633
00:24:41,330 --> 00:24:37,710
the other one that they're from Paul

634
00:24:46,220 --> 00:24:41,340
from astronomy and Jay comm what colors

635
00:24:48,710 --> 00:24:46,230
can stars start their lives as so you as

636
00:24:50,629 --> 00:24:48,720
I understand that you guys are saying

637
00:24:53,710 --> 00:24:50,639
that these stars in particular in this

638
00:24:56,299 --> 00:24:53,720

cluster in r134 these are starting as

639
00:24:59,320 --> 00:24:56,309
incredibly hot and therefore blue star

640
00:25:03,049 --> 00:24:59,330
that's what Fabien was telling us right

641
00:25:05,389 --> 00:25:03,059
yes so say that was probably a phase

642
00:25:07,340 --> 00:25:05,399
where the star started out more in the

643
00:25:09,499 --> 00:25:07,350
cooler Kazim but then very quickly

644
00:25:11,539 --> 00:25:09,509
equated all its mass and it immediately

645
00:25:13,789 --> 00:25:11,549
turns into something blue and short

646
00:25:17,060 --> 00:25:13,799
again on a time scale of stars of course

647
00:25:18,590 --> 00:25:17,070
so if you really think of so what it's

648
00:25:21,769 --> 00:25:18,600
probably the problem of how to define

649
00:25:23,869 --> 00:25:21,779
when a star gets into existence so when

650
00:25:26,060 --> 00:25:23,879
does the life of a star starts we would

651
00:25:27,830 --> 00:25:26,070
typically say well whenever in in the

652
00:25:30,080 --> 00:25:27,840
core and the interior you start to fuse

653
00:25:32,570 --> 00:25:30,090
hydrogen and at that point these stars

654
00:25:33,859 --> 00:25:32,580
are all extremely blue extremely hot but

655
00:25:36,379 --> 00:25:33,869
before that they had an accretion

656
00:25:38,810 --> 00:25:36,389
history and they're probably looking

657
00:25:42,470 --> 00:25:38,820
kind of reddish but we've never seen

658
00:25:44,570 --> 00:25:42,480
such an object forming yet so right so

659
00:25:47,419 --> 00:25:44,580
yeah I keep coming back to this we've

660
00:25:49,220 --> 00:25:47,429
seen the debates that we as someone was

661
00:25:52,070 --> 00:25:49,230
pointing out in astronomy 101 we counted

662
00:25:53,989 --> 00:25:52,080
it a simplified calculation to do this

663
00:25:55,669 --> 00:25:53,999

accretion model of this gas cloud coming

664
00:25:57,409 --> 00:25:55,679
together and forming whatever stars and

665
00:25:59,330 --> 00:25:57,419
I guess you could assume that you know

666
00:26:01,129 --> 00:25:59,340
red dwarf stars would not have started

667
00:26:02,539 --> 00:26:01,139
with this much material probably in a

668
00:26:04,729 --> 00:26:02,549
very remote region of the galaxy or

669
00:26:07,070 --> 00:26:04,739
whatever it is I don't and then the

670
00:26:09,340 --> 00:26:07,080
these stars obviously being break

671
00:26:12,859 --> 00:26:09,350
crowded and very dense and having a rich

672
00:26:15,109 --> 00:26:12,869
set of cross raw materials can create

673
00:26:18,019 --> 00:26:15,119
these very hot large and blue stars but

674
00:26:20,060 --> 00:26:18,029
even that by itself doesn't doesn't

675
00:26:23,119 --> 00:26:20,070
explain why they get so big and so this

676
00:26:25,369 --> 00:26:23,129
one sort of accretion our emerging model

677
00:26:27,080 --> 00:26:25,379
comes in there was another animation

678
00:26:29,450 --> 00:26:27,090
that I saw before the hangout started

679
00:26:32,149 --> 00:26:29,460
though is that relevant here to Selma

680
00:26:33,710 --> 00:26:32,159
with the there was an I don't recall

681
00:26:35,899 --> 00:26:33,720
what it what it said but there was

682
00:26:38,989 --> 00:26:35,909
another animation that you should we

683
00:26:39,740 --> 00:26:38,999
show I think Paul is proposing to show

684
00:26:42,620 --> 00:26:39,750
their compares

685
00:26:44,260 --> 00:26:42,630
between the Sun and Red Dwarf sir oh all

686
00:26:47,480 --> 00:26:44,270
right sure sure

687
00:26:49,070 --> 00:26:47,490
give me mama okay good okay all right I

688
00:26:50,390 --> 00:26:49,080

didn't know I can be please say

689
00:26:52,610 --> 00:26:50,400
something about this so just before

690
00:26:55,580 --> 00:26:52,620
these stars come in contact this is two

691
00:26:59,210 --> 00:26:55,590
two binary stars that are very close you

692
00:27:01,220 --> 00:26:59,220
see they're just system yeah so we think

693
00:27:03,110 --> 00:27:01,230
that most massive stars have companions

694
00:27:05,930 --> 00:27:03,120
like that it's very rarely we find them

695
00:27:09,320 --> 00:27:05,940
alone and so most normal massive stars

696
00:27:11,270 --> 00:27:09,330
are like this and they turn around each

697
00:27:13,130 --> 00:27:11,280
other like a planet around the Sun and

698
00:27:15,760 --> 00:27:13,140
then they start to interact which is

699
00:27:18,740 --> 00:27:15,770
what you just saw you saw one star

700
00:27:21,620 --> 00:27:18,750
throwing material to the other star some

701
00:27:23,000 --> 00:27:21,630
people call this a vampire system so

702
00:27:25,250 --> 00:27:23,010
this is something we think is a very

703
00:27:27,950 --> 00:27:25,260
common in massive stars the interesting

704
00:27:29,660 --> 00:27:27,960
thing is that these stars four hundred

705
00:27:31,850 --> 00:27:29,670
two hundred solar masses as far as we

706
00:27:34,760 --> 00:27:31,860
know now we don't see any companion

707
00:27:36,920 --> 00:27:34,770
which is actually very strange for a

708
00:27:38,240 --> 00:27:36,930
massive star for normal massive stars

709
00:27:41,090 --> 00:27:38,250
all have companions and these most

710
00:27:43,460 --> 00:27:41,100
massive stars so as far as we know today

711
00:27:44,600 --> 00:27:43,470
they don't have companions that kind of

712
00:27:45,710 --> 00:27:44,610
makes sense right I mean if they've

713
00:27:47,630 --> 00:27:45,720

already perished

714
00:27:49,280 --> 00:27:47,640
they've already might they might have

715
00:27:50,600 --> 00:27:49,290
already eaten their companion so one of

716
00:27:52,430 --> 00:27:50,610
the questions here is are they blue

717
00:27:54,620 --> 00:27:52,440
stragglers and yes that's exactly what

718
00:27:57,200 --> 00:27:54,630
we mean if if a star eats its companion

719
00:27:59,840 --> 00:27:57,210
you get a blue star that appears to be

720
00:28:00,890 --> 00:27:59,850
young it struggles behind the other star

721
00:28:02,780 --> 00:28:00,900
it struggles in time

722
00:28:04,160 --> 00:28:02,790
it looks younger than the other star so

723
00:28:05,750 --> 00:28:04,170
yes it's exactly what we call a blue

724
00:28:08,540 --> 00:28:05,760
straggler great that was from Richard

725
00:28:09,890 --> 00:28:08,550
Craig good question okay okay good so I

726
00:28:16,960 --> 00:28:09,900
want to get to their deaths in a minute

727
00:28:24,890 --> 00:28:21,290
Wow look at that so we have not just

728
00:28:26,090 --> 00:28:24,900
impression okay kind of different sizes

729
00:28:29,630 --> 00:28:26,100
of these different styles and the colors

730
00:28:31,430 --> 00:28:29,640
so so most stars in the universe in a

731
00:28:34,190 --> 00:28:31,440
Milky Way and other galaxies are these

732
00:28:35,870 --> 00:28:34,200
red dwarf stars which are not much

733
00:28:38,570 --> 00:28:35,880
bigger than Jupiter and kind of live

734
00:28:40,760 --> 00:28:38,580
forever you know they kind of keep going

735
00:28:42,350 --> 00:28:40,770
on like they're they may faint and so

736
00:28:44,600 --> 00:28:42,360
they like getting through their hydrogen

737
00:28:46,730 --> 00:28:44,610
fuel very quickly and they just keep on

738
00:28:48,260 --> 00:28:46,740

trucking forever you know and then we

739
00:28:51,430 --> 00:28:48,270
have the next size up that's going to

740
00:28:54,830 --> 00:28:51,440
some sort of savage

741
00:28:58,549 --> 00:28:54,840
which are still pretty common in in

742
00:29:00,529 --> 00:28:58,559
galaxies somewhat bigger you know so 10

743
00:29:02,450 --> 00:29:00,539
times bigger than Jupiter hundred times

744
00:29:05,719 --> 00:29:02,460
bigger than the earth these things have

745
00:29:08,269 --> 00:29:05,729
got lifetimes of 10 billion years of

746
00:29:09,680 --> 00:29:08,279
10,000 million years or so and then most

747
00:29:11,930 --> 00:29:09,690
when we think about massive stars in

748
00:29:13,849 --> 00:29:11,940
general it's that kind of kind of bleed

749
00:29:15,320 --> 00:29:13,859
warf so instead it's a dwarf there it's

750
00:29:17,719 --> 00:29:15,330
not a supergiant star but it's only a

751
00:29:19,999 --> 00:29:17,729
few times bigger than the Sun and may

752
00:29:22,969 --> 00:29:20,009
have a mass of 10 times the mass of the

753
00:29:25,999 --> 00:29:22,979
Sun these are pretty pretty rare and

754
00:29:27,440 --> 00:29:26,009
these things exist in um in in the RAI

755
00:29:29,539 --> 00:29:27,450
nebula for example the few of these

756
00:29:31,489 --> 00:29:29,549
things are in there but still pretty

757
00:29:33,830 --> 00:29:31,499
rare and these had lifetimes of many

758
00:29:35,479 --> 00:29:33,840
tens of millions of years and the kind

759
00:29:37,849 --> 00:29:35,489
of most massive stars are ones which are

760
00:29:40,609 --> 00:29:37,859
in that central cluster in the tarantula

761
00:29:44,479 --> 00:29:40,619
in our 36-hour things a bit like that

762
00:29:46,460 --> 00:29:44,489
but that darker blue cartoon showing

763
00:29:48,950 --> 00:29:46,470

showing what we think is right now the

764
00:29:51,409 --> 00:29:48,960
most massive star known and see if these

765
00:29:54,619 --> 00:29:51,419
are these are maybe 20 times bigger than

766
00:29:55,820 --> 00:29:54,629
the Sun but incredibly luminous and

767
00:29:57,259 --> 00:29:55,830
incredibly short-lived

768
00:30:01,009 --> 00:29:57,269
you know the lifetimes to be stars are

769
00:30:03,139 --> 00:30:01,019
only a few million years and so we have

770
00:30:04,789 --> 00:30:03,149
to look in the youngest artists have a

771
00:30:06,979 --> 00:30:04,799
chance of seeing them you know if a

772
00:30:08,479 --> 00:30:06,989
cluster is only a few million years old

773
00:30:09,969 --> 00:30:08,489
it would be too late these guys are

774
00:30:12,019 --> 00:30:09,979
already gone

775
00:30:13,759 --> 00:30:12,029
amazing look I'm sorry look how large

776
00:30:16,009 --> 00:30:13,769
that it was to you and it's because it's

777
00:30:17,299 --> 00:30:16,019
because they they're so they're shining

778
00:30:19,909 --> 00:30:17,309
so brightly you know they're they're

779
00:30:21,859 --> 00:30:19,919
using up their fuel so quickly which is

780
00:30:24,200 --> 00:30:21,869
why they are such short lifetimes you

781
00:30:26,359 --> 00:30:24,210
know so they you know they're they have

782
00:30:28,820 --> 00:30:26,369
a fuel supply of a hundred times the Sun

783
00:30:31,969 --> 00:30:28,830
in terms of its hydrogen but because

784
00:30:35,180 --> 00:30:31,979
they're shining up - it's a cases now

785
00:30:37,639 --> 00:30:35,190
a36 a one we think shines together ten

786
00:30:39,019 --> 00:30:37,649
million times brighter than the Sun you

787
00:30:40,549 --> 00:30:39,029
know it's going through its fuel so

788
00:30:44,899 --> 00:30:40,559

quickly they live fast and die greedy

789
00:30:50,629 --> 00:30:44,909
young okay and there is another graphic

790
00:30:51,739 --> 00:30:50,639
that we had on the as a pie chart I

791
00:30:53,060 --> 00:30:51,749
guess once you go ahead and put that up

792
00:30:56,989 --> 00:30:53,070
Scott and then I'll have

793
00:31:00,250 --> 00:30:56,999
Fabian watch it why don't you describe

794
00:31:02,560 --> 00:31:00,260
or whose is this whose whose

795
00:31:06,039 --> 00:31:02,570
graphic is this yours Paul or whoever

796
00:31:07,870 --> 00:31:06,049
wants to talk about it I'm just I've

797
00:31:11,889 --> 00:31:07,880
made a gun I made it by tired but I let

798
00:31:16,330 --> 00:31:11,899
far beyond the explain explain so much

799
00:31:19,810 --> 00:31:16,340
pie talk to us so the pie chart looks

800
00:31:22,990 --> 00:31:19,820
like a cake someone's getting hungry no

801
00:31:25,810 --> 00:31:23,000
I don't know that would be any help I'm

802
00:31:28,389 --> 00:31:25,820
a little hungry over here hungry oh oh

803
00:31:31,930 --> 00:31:28,399
you can try it Neal afterwards I don't

804
00:31:33,310 --> 00:31:31,940
know well so what was found

805
00:31:35,710 --> 00:31:33,320
what some of it was is what this was

806
00:31:37,240 --> 00:31:35,720
describing is so most of the stars have

807
00:31:38,830 --> 00:31:37,250
you see in the universe massive stars

808
00:31:43,180 --> 00:31:38,840
they all have a companion so they don't

809
00:31:45,940 --> 00:31:43,190
live alone and it turns out that maybe

810
00:31:49,269 --> 00:31:45,950
1/3 of them or 29% as it is written down

811
00:31:51,370 --> 00:31:49,279
in this pie chart now only sort of live

812
00:31:54,070 --> 00:31:51,380
their life without ever seeing their

813
00:31:56,440 --> 00:31:54,080

companion really here to close or doing

814
00:31:58,360 --> 00:31:56,450
anything with it and all the other stars

815
00:31:59,799 --> 00:31:58,370
the other 2/3 they are doing something

816
00:32:02,500 --> 00:31:59,809
with their companions and you've seen

817
00:32:04,810 --> 00:32:02,510
our two animations already for example

818
00:32:07,210 --> 00:32:04,820
if you look in the into the into the

819
00:32:09,009 --> 00:32:07,220
animation we had just before that was

820
00:32:10,930 --> 00:32:09,019
his mass transfer in binary so there was

821
00:32:13,919 --> 00:32:10,940
just this vampire star sucking of

822
00:32:16,210 --> 00:32:13,929
material from from its companion and

823
00:32:17,500 --> 00:32:16,220
these are these stars that we have in

824
00:32:21,100 --> 00:32:17,510
this pie chart on the top right and

825
00:32:23,049 --> 00:32:21,110
bottom right so you see this mass being

826
00:32:25,120 --> 00:32:23,059
transferred and while you transfer mass

827
00:32:26,560 --> 00:32:25,130
or form um object to the other that

828
00:32:28,539 --> 00:32:26,570
means also you are stripping off its

829
00:32:30,700 --> 00:32:28,549
envelope so you revealing all the deep

830
00:32:32,830 --> 00:32:30,710
insights that have been burnt to helium

831
00:32:35,830 --> 00:32:32,840
into other elements and that can then

832
00:32:38,409 --> 00:32:35,840
explode in various ways and then this

833
00:32:40,210 --> 00:32:38,419
mass accretions stream will then as it

834
00:32:41,649 --> 00:32:40,220
was also shown in the animation spin up

835
00:32:43,180 --> 00:32:41,659
the companion because you're not only

836
00:32:46,090 --> 00:32:43,190
transferring mass but also angular

837
00:32:48,549 --> 00:32:46,100
momentum so it's like this ice skater

838
00:32:51,850 --> 00:32:48,559

that it's getting kind of mass now and

839
00:32:53,320 --> 00:32:51,860
then it spins up and that's what these

840
00:32:55,120 --> 00:32:53,330
stars - and then we've seen the other

841
00:32:57,039 --> 00:32:55,130
animation where the two stars get into

842
00:32:59,560 --> 00:32:57,049
contact or the kissing binaries that's a

843
00:33:02,080 --> 00:32:59,570
lower left region of this diagram and

844
00:33:05,019 --> 00:33:02,090
we'll think that roughly well maybe 1/4

845
00:33:07,840 --> 00:33:05,029
of all the stars that are born in Essos

846
00:33:09,639 --> 00:33:07,850
stars as hot messes stars that 1/4 maybe

847
00:33:12,530 --> 00:33:09,649
is merging with their companion and

848
00:33:14,390 --> 00:33:12,540
that's also what we think what could

849
00:33:19,220 --> 00:33:14,400
happened to maybe one or two of these

850
00:33:21,560 --> 00:33:19,230
beasts in our 156 ok well that's that

851
00:33:23,060 --> 00:33:21,570
that leads me now to another question

852
00:33:25,400 --> 00:33:23,070
that this is coming from John Willis on

853
00:33:27,920 --> 00:33:25,410
YouTube he's going he's asking about the

854
00:33:30,620 --> 00:33:27,930
metallicity of the stars and the gas

855
00:33:33,350 --> 00:33:30,630
clouds and if they're you know are they

856
00:33:34,760 --> 00:33:33,360
low or are they high so I probably get

857
00:33:36,350 --> 00:33:34,770
you in on this can you describe to us

858
00:33:39,530 --> 00:33:36,360
what it what it is first of all tell us

859
00:33:41,210 --> 00:33:39,540
what metallicity means and then maybe

860
00:33:42,740 --> 00:33:41,220
talking what are what are the

861
00:33:47,240 --> 00:33:42,750
metallicity of these stars do we know

862
00:33:49,310 --> 00:33:47,250
sure so so astronomers talk about metals

863
00:33:51,620 --> 00:33:49,320

metals what I'm is very different from

864
00:33:55,490 --> 00:33:51,630
what chemists might talk about different

865
00:33:58,430 --> 00:33:55,500
I learned anything which isn't hydrogen

866
00:34:03,530 --> 00:33:58,440
or helium is a metal so it's oxygen

867
00:34:08,060 --> 00:34:03,540
carbon iron nitrogen these elements and

868
00:34:10,370 --> 00:34:08,070
so in in this in our sole neighborhood

869
00:34:13,190 --> 00:34:10,380
the servants composition is mostly

870
00:34:17,180 --> 00:34:13,200
hydrogen helium with one one bit percent

871
00:34:20,440 --> 00:34:17,190
metals it's the same in the Orion Nebula

872
00:34:23,150 --> 00:34:20,450
where those stars are forming only a few

873
00:34:26,450 --> 00:34:23,160
thousand one thousand light years away

874
00:34:29,690 --> 00:34:26,460
in the in the LMC the present-day metal

875
00:34:33,230 --> 00:34:29,700
content is about half that of the solar

876
00:34:36,919 --> 00:34:33,240
neighborhood so it sits below the metal

877
00:34:40,310 --> 00:34:36,929
content of our local parts of Milky Way

878
00:34:43,419 --> 00:34:40,320
but it slowly a factor of two are there

879
00:34:46,130 --> 00:34:43,429
are places where the metal content is a

880
00:34:48,169 --> 00:34:46,140
hundred times lower you know very

881
00:34:50,330 --> 00:34:48,179
extreme places other places where it's a

882
00:34:54,050 --> 00:34:50,340
factor of a few higher but really it's

883
00:34:56,060 --> 00:34:54,060
it's fairly similar to our own part of

884
00:34:57,920 --> 00:34:56,070
the Milky Way a little bit about only a

885
00:34:59,900 --> 00:34:57,930
little bit ok good well where I want to

886
00:35:02,570 --> 00:34:59,910
go with this now is I want we've all

887
00:35:04,130 --> 00:35:02,580
heard about Jay the James Webb Space

888
00:35:06,440 --> 00:35:04,140

Telescope and the fact that it's going

889
00:35:08,540 --> 00:35:06,450
to be looking at the first galaxies and

890
00:35:09,950 --> 00:35:08,550
also the first stars and one of the

891
00:35:11,780 --> 00:35:09,960
things about the very first stars in the

892
00:35:13,250 --> 00:35:11,790
universe is that they are known for

893
00:35:15,200 --> 00:35:13,260
having their very low metallicity

894
00:35:16,700 --> 00:35:15,210
primarily hydrogen and helium and in the

895
00:35:19,490 --> 00:35:16,710
early universe was all they had to work

896
00:35:21,530 --> 00:35:19,500
with and so those stars are they when I

897
00:35:24,080 --> 00:35:21,540
hear you guys talk about the stars in

898
00:35:25,020 --> 00:35:24,090
this cluster it reminds me a lot about

899
00:35:26,610 --> 00:35:25,030
what I've learned

900
00:35:27,990 --> 00:35:26,620
heard about the James Webb Space

901
00:35:30,360 --> 00:35:28,000
Telescope was going to show us for the

902
00:35:32,580 --> 00:35:30,370
first stars and Paul you're just saying

903
00:35:35,220 --> 00:35:32,590
that they are about a factor of two

904
00:35:36,990 --> 00:35:35,230
lowering metallicity from our own but it

905
00:35:38,850 --> 00:35:37,000
sounds to me like there's some pretty

906
00:35:42,210 --> 00:35:38,860
big differences so what can you compare

907
00:35:46,080 --> 00:35:42,220
these stars was with what the very first

908
00:35:47,580 --> 00:35:46,090
stars would be like sure so I mean the

909
00:35:49,320 --> 00:35:47,590
kind of things which Hubble can do right

910
00:35:51,870 --> 00:35:49,330
now we're looking at the these these

911
00:35:53,820 --> 00:35:51,880
very early protocol X's what we call

912
00:35:58,650 --> 00:35:53,830
high redshift where shift of five or so

913
00:36:01,920 --> 00:35:58,660

I can do right now 10h of 10 these are

914
00:36:03,630 --> 00:36:01,930
these are things which I would say the

915
00:36:05,250 --> 00:36:03,640
kind of star formation because there's

916
00:36:06,390 --> 00:36:05,260
an awful lot of gas the star formation

917
00:36:09,450 --> 00:36:06,400
that's going on in those high-redshift

918
00:36:11,160 --> 00:36:09,460
galaxies is to me very similar to

919
00:36:14,580 --> 00:36:11,170
actually what's going on within the kind

920
00:36:16,980 --> 00:36:14,590
of tarantula you know tarantulas a very

921
00:36:20,970 --> 00:36:16,990
violent style forming place compared to

922
00:36:23,670 --> 00:36:20,980
our own very quiet lone star formation

923
00:36:25,260 --> 00:36:23,680
going on in our Milky Way so to me the

924
00:36:27,840 --> 00:36:25,270
tarantula is a good kind of template

925
00:36:30,180 --> 00:36:27,850
really for for typical star formation

926
00:36:31,800 --> 00:36:30,190
going on in these hybrid galaxies but if

927
00:36:33,240 --> 00:36:31,810
you want to go to the first galaxies of

928
00:36:34,950 --> 00:36:33,250
course they're the ones where there's no

929
00:36:36,720 --> 00:36:34,960
metals so you're looking at stars

930
00:36:39,390 --> 00:36:36,730
forming out of purely hydrogen and

931
00:36:43,260 --> 00:36:39,400
helium and we think that those stars are

932
00:36:46,650 --> 00:36:43,270
much more compact than those we see in a

933
00:36:48,420 --> 00:36:46,660
tarantula in our own Milky Way and and

934
00:36:50,850 --> 00:36:48,430
also therefore much more compact much

935
00:36:53,490 --> 00:36:50,860
hotter and we think probably also much

936
00:36:55,080 --> 00:36:53,500
higher mass on average you know that

937
00:36:57,060 --> 00:36:55,090
that image I showed you which showed the

938
00:37:01,980 --> 00:36:57,070

kind of typical Styles being a red dwarf

939
00:37:03,390 --> 00:37:01,990
you know a tenth of a solar mass and we

940
00:37:05,460 --> 00:37:03,400
think that probably the typical stars

941
00:37:07,020 --> 00:37:05,470
forming the first stars forming that

942
00:37:11,010 --> 00:37:07,030
James whoever should be able to kind of

943
00:37:15,780 --> 00:37:11,020
hopefully get get get to are probably

944
00:37:20,370 --> 00:37:15,790
typically the kind of blue more massive

945
00:37:21,990 --> 00:37:20,380
than the Sun so so quite the the messes

946
00:37:24,570 --> 00:37:22,000
we don't quite know what a typical mass

947
00:37:26,850 --> 00:37:24,580
of these first generations of stars are

948
00:37:28,440 --> 00:37:26,860
like well I heard it was more or less

949
00:37:30,660 --> 00:37:28,450
like what we're talking about here 100

950
00:37:32,430 --> 00:37:30,670
200 times yeah that the original

951
00:37:34,200 --> 00:37:32,440
simulation seemed to say typical stars

952
00:37:36,930 --> 00:37:34,210
where maybe a hundred times the mass of

953
00:37:38,299 --> 00:37:36,940
the Sun but the more modern simulations

954
00:37:41,660 --> 00:37:38,309
seem to say may have some way

955
00:37:44,839 --> 00:37:41,670
maybe what water 10 maybe but certainly

956
00:37:46,549 --> 00:37:44,849
those 10 Solomon stars would be much

957
00:37:49,309 --> 00:37:46,559
more compact and therefore emitting a

958
00:37:50,989 --> 00:37:49,319
lot of their energy in the ultraviolet a

959
00:37:53,239 --> 00:37:50,999
bit like these these guys in the

960
00:37:54,799 --> 00:37:53,249
tarantula and of course that light gets

961
00:37:57,289 --> 00:37:54,809
redshifted you know looking at a

962
00:38:00,049 --> 00:37:57,299
redshift 20 galaxies as they shifted out

963
00:38:04,039 --> 00:38:00,059

into the near infrared where where James

964
00:38:06,289 --> 00:38:04,049
Webb will really really explain its

965
00:38:07,999 --> 00:38:06,299
large angular size and collecting area

966
00:38:10,279 --> 00:38:08,009
yeah and I guess that's where the

967
00:38:11,929 --> 00:38:10,289
comparison kind of start because the the

968
00:38:13,579 --> 00:38:11,939
reason James Webb is going to be an

969
00:38:15,109 --> 00:38:13,589
infrared telescope is like you say a lot

970
00:38:17,299 --> 00:38:15,119
of these things that were very bright in

971
00:38:19,699 --> 00:38:17,309
the ultraviolet have red shifted into

972
00:38:22,459 --> 00:38:19,709
the infrared it's not going to be much

973
00:38:24,890 --> 00:38:22,469
help is it for looking at this

974
00:38:26,299 --> 00:38:24,900
particular cluster one if you wouldn't

975
00:38:27,709 --> 00:38:26,309
let's say they launched change web and

976
00:38:30,019 --> 00:38:27,719
one of them somebody comes up with a

977
00:38:33,079 --> 00:38:30,029
proposal I want to look at are 134 with

978
00:38:34,819 --> 00:38:33,089
this I'm what are they gonna see much

979
00:38:38,329 --> 00:38:34,829
are they because this is primarily a UV

980
00:38:40,099 --> 00:38:38,339
target well the most luminous stars are

981
00:38:42,229 --> 00:38:40,109
UV bright but they're still pretty

982
00:38:44,179 --> 00:38:42,239
bright in the infrared we've observed

983
00:38:46,759 --> 00:38:44,189
this cluster with their own eyes

984
00:38:48,859 --> 00:38:46,769
telescope in the infrared and it's got a

985
00:38:53,419 --> 00:38:48,869
similar resorbing similar angular

986
00:38:55,069 --> 00:38:53,429
resolving power to Hubble and so you can

987
00:38:57,319 --> 00:38:55,079
observe these things in the infrared but

988
00:38:59,539 --> 00:38:57,329

of course most of energy is Fabien

989
00:39:02,539 --> 00:38:59,549
mentioned earlier is being pumped out in

990
00:39:04,400 --> 00:39:02,549
the ultraviolet and so Yuri ideally hot

991
00:39:05,839 --> 00:39:04,410
always perfect in terms of looking at

992
00:39:09,079 --> 00:39:05,849
these styles where they're brightest in

993
00:39:10,489 --> 00:39:09,089
the ultraviolet part of the spectrum and

994
00:39:12,289 --> 00:39:10,499
it's only those guys which then when you

995
00:39:14,569 --> 00:39:12,299
look at those in hi Reggie can access

996
00:39:16,009 --> 00:39:14,579
that light gets red shifted out towards

997
00:39:18,650 --> 00:39:16,019
infrared wavelengths which James Webb

998
00:39:20,299 --> 00:39:18,660
will be able to exploit I keep saying

999
00:39:20,809 --> 00:39:20,309
134 I don't know why I do you know why I

1000
00:39:22,789 --> 00:39:20,819
do that

1001
00:39:25,339 --> 00:39:22,799
you know what are 136 reminds me of it

1002
00:39:29,089 --> 00:39:25,349
reminds me of a refrigerant are 134

1003
00:39:32,179 --> 00:39:29,099
which I put in my air conditioner that's

1004
00:39:37,400 --> 00:39:32,189
really like 130 or so my apologies for

1005
00:39:38,929 --> 00:39:37,410
doing that I see are at 130 oh it's a

1006
00:39:41,479 --> 00:39:38,939
little warmer than that just a little

1007
00:39:43,249 --> 00:39:41,489
bit yeah I get that it's yeah so anyway

1008
00:39:45,679 --> 00:39:43,259
that's why I keep doing that I my

1009
00:39:47,299 --> 00:39:45,689
apologies for it for mispronouncing it

1010
00:39:49,640 --> 00:39:47,309
so let's go to the next stage so we know

1011
00:39:52,160 --> 00:39:49,650
these are these are being born in a very

1012
00:39:54,079 --> 00:39:52,170
rich area in the Large Magellanic Cloud

1013
00:39:55,960 --> 00:39:54,089

and nebula we know they're very large we

1014
00:39:59,589 --> 00:39:55,970
don't know quite how they got that big

1015
00:40:03,109 --> 00:39:59,599
but they are that big to 100 250 times

1016
00:40:04,910 --> 00:40:03,119
more massive than our Sun and Jeffrey

1017
00:40:08,120 --> 00:40:04,920
knee is asking is it impossible for a

1018
00:40:10,490 --> 00:40:08,130
star to gather 100 plus solar masses as

1019
00:40:12,680 --> 00:40:10,500
it travels through the nebula and I

1020
00:40:15,440 --> 00:40:12,690
think the answer to that is no cuz

1021
00:40:17,690 --> 00:40:15,450
they're there plenty of men right I mean

1022
00:40:20,329 --> 00:40:17,700
how would you answer that salma yeah

1023
00:40:22,010 --> 00:40:20,339
just gathering it by flying through a

1024
00:40:25,579 --> 00:40:22,020
cloud it's not helping this stars

1025
00:40:28,150 --> 00:40:25,589
shining and so actually it would blow

1026
00:40:30,980 --> 00:40:28,160
off material of the cloud it's shaping

1027
00:40:33,260 --> 00:40:30,990
holes it's making these what I could

1028
00:40:35,180 --> 00:40:33,270
cover Swiss cheese bubbles in these

1029
00:40:37,520 --> 00:40:35,190
clouds so no it cannot accrete it by

1030
00:40:41,270 --> 00:40:37,530
just moving through the crowd so it has

1031
00:40:43,730 --> 00:40:41,280
to get it either at formation or like

1032
00:40:45,710 --> 00:40:43,740
usually when it's reform when it's very

1033
00:40:47,420 --> 00:40:45,720
young when it's not really shining that

1034
00:40:48,770 --> 00:40:47,430
brightly and it's not that hot yet that

1035
00:40:51,349 --> 00:40:48,780
would be the moment when it can maybe

1036
00:40:52,940 --> 00:40:51,359
accrete and it would help over probably

1037
00:40:54,799 --> 00:40:52,950
when it's sitting in a dense center of

1038
00:40:56,150 --> 00:40:54,809

that star cluster and the gravity of all

1039
00:40:59,420 --> 00:40:56,160
these stars together maybe that's

1040
00:41:03,680 --> 00:40:59,430
helping in parts to to attract all these

1041
00:41:05,480 --> 00:41:03,690
gas clouds to fall into the gravity or

1042
00:41:07,490 --> 00:41:05,490
attracted by the gravity of these

1043
00:41:08,829 --> 00:41:07,500
combined stars well I have to ask this

1044
00:41:10,609 --> 00:41:08,839
because we're very enamored with

1045
00:41:14,450 --> 00:41:10,619
exoplanets these days what are the

1046
00:41:16,730 --> 00:41:14,460
planet prospects inside so the James

1047
00:41:18,680 --> 00:41:16,740
Webb is not maybe not I mean we would

1048
00:41:23,210 --> 00:41:18,690
love or UV telescope to be the next

1049
00:41:24,770 --> 00:41:23,220
telescope is gonna do great things for

1050
00:41:26,480 --> 00:41:24,780
for massive stars when they're slightly

1051
00:41:29,000 --> 00:41:26,490
younger and and something else you could

1052
00:41:31,280 --> 00:41:29,010
do if you would look in the infrared

1053
00:41:33,200 --> 00:41:31,290
these stars you would these stars it's

1054
00:41:35,000 --> 00:41:33,210
annoying they're so bright because it's

1055
00:41:37,460 --> 00:41:35,010
very hard to study what are the low mass

1056
00:41:39,140 --> 00:41:37,470
stars right next to it doing so if you

1057
00:41:40,940 --> 00:41:39,150
look in the infrared it would be a

1058
00:41:44,450 --> 00:41:40,950
really nice way to sort of put sun

1059
00:41:45,770 --> 00:41:44,460
shades sunglasses on to make the blue

1060
00:41:47,480 --> 00:41:45,780
stars a little bit dimmer so you can

1061
00:41:49,700 --> 00:41:47,490
actually see the low mass stars next to

1062
00:41:52,099 --> 00:41:49,710
it so I saw there was one question of

1063
00:41:54,530 --> 00:41:52,109

could such a massive star have a planet

1064
00:41:56,900 --> 00:41:54,540
that is unlikely because you need time

1065
00:41:59,780 --> 00:41:56,910
to form a planet and it's not helping if

1066
00:42:01,609 --> 00:41:59,790
the star shining so bright but these

1067
00:42:04,059 --> 00:42:01,619
stars may have tiny tiny little

1068
00:42:06,020 --> 00:42:04,069
companion stars that is kind of planets

1069
00:42:08,870 --> 00:42:06,030
and so it would help to

1070
00:42:11,660 --> 00:42:08,880
looking redder wavelengths to us to look

1071
00:42:13,580 --> 00:42:11,670
for these Lomas companions but I can't

1072
00:42:16,280 --> 00:42:13,590
imagine the environment in that star

1073
00:42:18,740 --> 00:42:16,290
cluster being all that habitable for any

1074
00:42:21,530 --> 00:42:18,750
planet so my feet in there but that's

1075
00:42:24,110 --> 00:42:21,540
just a guess that I would have so okay

1076
00:42:25,520 --> 00:42:24,120
well so we we don't there it's possible

1077
00:42:27,050 --> 00:42:25,530
that there are planets in there there's

1078
00:42:28,910 --> 00:42:27,060
also pot there's certainly lower mass

1079
00:42:30,680 --> 00:42:28,920
stars going on and shining in there as

1080
00:42:32,060 --> 00:42:30,690
well and as someone points out it'd be

1081
00:42:34,790 --> 00:42:32,070
great if we could maybe turn it down a

1082
00:42:38,090 --> 00:42:34,800
notch or two to take a look but it's not

1083
00:42:40,310 --> 00:42:38,100
that's not something we can be right I

1084
00:42:42,020 --> 00:42:40,320
mean as we're seeing here this is the

1085
00:42:43,010 --> 00:42:42,030
same area looking through VLT as we're

1086
00:42:44,990 --> 00:42:43,020
talking about for the Very Large

1087
00:42:47,570 --> 00:42:45,000
Telescope so as we're seeing in that

1088
00:42:49,070 --> 00:42:47,580

class they're just very blown out I'm

1089
00:42:51,770 --> 00:42:49,080
not able to resolve as well as we were

1090
00:42:53,480 --> 00:42:51,780
able to with with Hubble in the UV so

1091
00:42:55,460 --> 00:42:53,490
the cluster is that little dot right in

1092
00:42:57,770 --> 00:42:55,470
the center there is that bright that

1093
00:42:59,270 --> 00:42:57,780
bright dot in the center right so it's a

1094
00:43:01,100 --> 00:42:59,280
little you know a little different what

1095
00:43:03,830 --> 00:43:01,110
we're able to see with the most recent

1096
00:43:05,930 --> 00:43:03,840
one but I saying it is pretty bright in

1097
00:43:09,530 --> 00:43:05,940
infrared but we're not able to resolve

1098
00:43:12,200 --> 00:43:09,540
that stuff in the UV okay all right Tony

1099
00:43:13,760 --> 00:43:12,210
yeah about planets came up and so just

1100
00:43:16,940 --> 00:43:13,770
to give you a sense just to give you the

1101
00:43:19,550 --> 00:43:16,950
people a sense about what if you were a

1102
00:43:21,470 --> 00:43:19,560
planet hypothetical planet orbiting one

1103
00:43:26,480 --> 00:43:21,480
of these guys if you put you know if you

1104
00:43:28,310 --> 00:43:26,490
put the earth the same distance as from

1105
00:43:30,770 --> 00:43:28,320
one three six a one on one is other very

1106
00:43:31,970 --> 00:43:30,780
massive stars as it's from the Sun it

1107
00:43:33,740 --> 00:43:31,980
would it would not if it was to be

1108
00:43:36,620 --> 00:43:33,750
remain bound it would orbit in about

1109
00:43:41,420 --> 00:43:36,630
three weeks sorry yeah would be three

1110
00:43:48,320 --> 00:43:41,430
weeks on gonna make Tony even older than

1111
00:43:50,150 --> 00:43:48,330
he is now yes but the ocean is not to

1112
00:43:51,920 --> 00:43:50,160
boil away we'd have to put the earth

1113
00:43:55,250 --> 00:43:51,930

about a thousand over a thousand times

1114
00:43:56,840 --> 00:43:55,260
further away than the earth is for it

1115
00:43:59,150 --> 00:43:56,850
because there's huge radiation coming

1116
00:44:00,140 --> 00:43:59,160
from the star okay I don't want to go

1117
00:44:02,960 --> 00:44:00,150
off on rent here

1118
00:44:04,280 --> 00:44:02,970
but with with the exoplanets that we've

1119
00:44:06,920 --> 00:44:04,290
been learning about they all seem to

1120
00:44:10,130 --> 00:44:06,930
have these ridiculously short years

1121
00:44:12,590 --> 00:44:10,140
eighteen days two weeks three weeks four

1122
00:44:14,510 --> 00:44:12,600
mean that's just that's just crazy and I

1123
00:44:16,340 --> 00:44:14,520
mean you're right I don't even want to

1124
00:44:19,549 --> 00:44:16,350
think about how old I would be on a

1125
00:44:21,439 --> 00:44:19,559
planet with a year of only

1126
00:44:23,179 --> 00:44:21,449
eighteen days so you could just have all

1127
00:44:25,670 --> 00:44:23,189
that but anyway the calculation to make

1128
00:44:27,069 --> 00:44:25,680
any mess that's not let's just move

1129
00:44:31,309 --> 00:44:27,079
right along

1130
00:44:36,609 --> 00:44:31,319
okay so Fabian I want I want to talk

1131
00:44:45,529 --> 00:44:36,619
about how these stars are gonna die what

1132
00:44:47,120 --> 00:44:45,539
excellent question so we've got these

1133
00:44:49,479 --> 00:44:47,130
stars I don't they're bright they're hot

1134
00:44:52,640 --> 00:44:49,489
they're young they're huge they're

1135
00:44:55,640 --> 00:44:52,650
they're they're running out of fuel very

1136
00:44:57,319 --> 00:44:55,650
quickly the masses imply a lot of really

1137
00:44:58,939 --> 00:44:57,329
cool things when they run out start to

1138
00:45:00,049 --> 00:44:58,949

run out of fuel museum their lives so

1139
00:45:02,900 --> 00:45:00,059
what do you guys think will happen

1140
00:45:05,269 --> 00:45:02,910
exactly so the really interesting bit of

1141
00:45:07,640 --> 00:45:05,279
the Toronto net nebula is that it is at

1142
00:45:09,739 --> 00:45:07,650
a lower metallicity and the lower

1143
00:45:13,219 --> 00:45:09,749
melissa metallicity usually allows for

1144
00:45:15,799 --> 00:45:13,229
really crazy explosions of stars so say

1145
00:45:17,120 --> 00:45:15,809
in our own Milky Way backyard I guess

1146
00:45:19,249 --> 00:45:17,130
what we would have in the end of the

1147
00:45:20,959 --> 00:45:19,259
stellar life is that it's core collapses

1148
00:45:23,299 --> 00:45:20,969
so it's a classical core collapse

1149
00:45:24,979 --> 00:45:23,309
supernova as we would call it so what's

1150
00:45:27,380 --> 00:45:24,989
happening there is the star it's just

1151
00:45:29,269 --> 00:45:27,390
fusing all its fuel so it start our the

1152
00:45:31,130 --> 00:45:29,279
hydrogen convert it into helium and then

1153
00:45:33,049 --> 00:45:31,140
takes the helium further converts it

1154
00:45:35,449 --> 00:45:33,059
into carbon and oxygen and it goes on

1155
00:45:36,859 --> 00:45:35,459
and on and on until you hit a silicon

1156
00:45:39,679 --> 00:45:36,869
burning and the silicon burning is

1157
00:45:42,650 --> 00:45:39,689
converting everything into iron now with

1158
00:45:46,459 --> 00:45:42,660
I and you have a problem from I infusion

1159
00:45:49,759 --> 00:45:46,469
you cannot get any energy out over this

1160
00:45:53,630 --> 00:45:49,769
star is suddenly robbed of its energy

1161
00:45:54,829 --> 00:45:53,640
source and so it has to collapse and and

1162
00:45:57,859 --> 00:45:54,839
this is what we then call a core

1163
00:46:00,410 --> 00:45:57,869

collapse supernova it's a classical way

1164
00:46:03,469 --> 00:46:00,420
of a star to die and at low metallicity

1165
00:46:06,079 --> 00:46:03,479
z-- you have a well one more fancy way

1166
00:46:08,029 --> 00:46:06,089
to die if you like well in fact I would

1167
00:46:10,489 --> 00:46:08,039
say to two further ways that you can die

1168
00:46:11,809 --> 00:46:10,499
and the one is probably the path that we

1169
00:46:13,969 --> 00:46:11,819
would call a long-duration gamma-ray

1170
00:46:15,799 --> 00:46:13,979
burst I will come to that in a second

1171
00:46:17,569 --> 00:46:15,809
and the other one which is also

1172
00:46:20,179 --> 00:46:17,579
extremely fancy as a pair instability

1173
00:46:23,329 --> 00:46:20,189
supernova so let me first discuss his

1174
00:46:25,099 --> 00:46:23,339
parents ability a supernova so what is

1175
00:46:27,650 --> 00:46:25,109
happening here is the star is still

1176
00:46:29,390 --> 00:46:27,660
burning it's its fuel so it's at having

1177
00:46:31,130 --> 00:46:29,400
maybe a lot of helium in its core

1178
00:46:33,500 --> 00:46:31,140
so we're speaking of a core mass now

1179
00:46:35,870 --> 00:46:33,510
that is above say 60 times

1180
00:46:37,609 --> 00:46:35,880
or son just the core of a star so

1181
00:46:41,090 --> 00:46:37,619
there's still an envelope sitting on top

1182
00:46:43,099 --> 00:46:41,100
and once you're hitting them this helium

1183
00:46:46,970 --> 00:46:43,109
burning and later on into the carbon and

1184
00:46:50,000 --> 00:46:46,980
oxygen burning the interior of the star

1185
00:46:53,240 --> 00:46:50,010
is so hot that all its photons or some

1186
00:46:56,390 --> 00:46:53,250
of its photons can produce l2 and

1187
00:46:58,580 --> 00:46:56,400
positron pairs this pair creation and

1188
00:47:00,260 --> 00:46:58,590

you need to know now that this interior

1189
00:47:03,380 --> 00:47:00,270
of such stars is balanced by the

1190
00:47:05,210 --> 00:47:03,390
radiation so they are variation power

1191
00:47:07,460 --> 00:47:05,220
balance to the radiation pressure from

1192
00:47:10,550 --> 00:47:07,470
all the photons in the inside is keeping

1193
00:47:12,109 --> 00:47:10,560
up or battling gravity if you like but

1194
00:47:13,430 --> 00:47:12,119
now you're taking away these photons

1195
00:47:15,200 --> 00:47:13,440
because you're producing a bit of

1196
00:47:16,310 --> 00:47:15,210
electrons and positrons and suddenly

1197
00:47:19,250 --> 00:47:16,320
what's going to happen is that they

1198
00:47:22,010 --> 00:47:19,260
start contracts extremely fast it

1199
00:47:23,660 --> 00:47:22,020
contracts its heat heating up and so

1200
00:47:26,450 --> 00:47:23,670
you're hitting a regime where you have

1201
00:47:28,280 --> 00:47:26,460
an explosive nuclear burning and what it

1202
00:47:30,380 --> 00:47:28,290
really means is that these objects

1203
00:47:33,349 --> 00:47:30,390
everything in it in the inside are going

1204
00:47:35,870 --> 00:47:33,359
to be burned into iron elements and this

1205
00:47:37,460 --> 00:47:35,880
energy release is usually then enough to

1206
00:47:40,430 --> 00:47:37,470
unbind the whole star and you can have

1207
00:47:42,290 --> 00:47:40,440
an extraordinary bright explosion in

1208
00:47:45,859 --> 00:47:42,300
particular you can produce maybe up to

1209
00:47:48,349 --> 00:47:45,869
10 solar masses of nickel and maybe you

1210
00:47:50,390 --> 00:47:48,359
know nickel is a radioactive element so

1211
00:47:52,099 --> 00:47:50,400
it's going to decay and this decay of

1212
00:47:54,230 --> 00:47:52,109
all this tensile amounts of nickel for

1213
00:47:55,940 --> 00:47:54,240

example that is powering a light curve

1214
00:47:57,550 --> 00:47:55,950
and a supernova that is extremely bright

1215
00:48:00,740 --> 00:47:57,560
and that's why we call them

1216
00:48:03,140 --> 00:48:00,750
superluminous supernova yeah give me a

1217
00:48:07,340 --> 00:48:03,150
fancy name but it's one way of for these

1218
00:48:09,349 --> 00:48:07,350
guys to die and so I just want to point

1219
00:48:11,180 --> 00:48:09,359
out also these parent stability

1220
00:48:12,950 --> 00:48:11,190
supernova that you're talking about is

1221
00:48:14,570 --> 00:48:12,960
also what's going to happen to the very

1222
00:48:17,030 --> 00:48:14,580
first stars I mean that's also what

1223
00:48:19,640 --> 00:48:17,040
they're about so again there's a lot of

1224
00:48:21,050 --> 00:48:19,650
parallels between this research and the

1225
00:48:23,000 --> 00:48:21,060
early universe and it all has to do with

1226
00:48:25,670 --> 00:48:23,010
the level of metallicity and stars

1227
00:48:27,109 --> 00:48:25,680
correct exactly I should adhere that at

1228
00:48:29,330 --> 00:48:27,119
the metallicity of the Large Magellanic

1229
00:48:31,580 --> 00:48:29,340
Cloud we do not think that these stars

1230
00:48:33,290 --> 00:48:31,590
are ending up as a pain so pretty superb

1231
00:48:34,550 --> 00:48:33,300
yeah okay go so probably what's going to

1232
00:48:36,140 --> 00:48:34,560
happen is that their stellar winds

1233
00:48:38,030 --> 00:48:36,150
they're too strong so this star is

1234
00:48:40,790 --> 00:48:38,040
losing all its mass so we will never

1235
00:48:43,460 --> 00:48:40,800
have a core mass of helium above this 60

1236
00:48:45,830 --> 00:48:43,470
or 65 solar masses so it cannot go this

1237
00:48:46,880 --> 00:48:45,840
path but if you just go maybe I don't

1238
00:48:49,759 --> 00:48:46,890

know a factor to

1239
00:48:53,450 --> 00:48:49,769
three lower mid Lissa T and it's already

1240
00:48:55,309 --> 00:48:53,460
the regime where you can do it well the

1241
00:48:58,450 --> 00:48:55,319
other one the long location gamma-ray

1242
00:49:02,059 --> 00:48:58,460
bursts it's also really fun thing and

1243
00:49:06,799 --> 00:49:02,069
let that sound fun Fabian because I'll

1244
00:49:12,319 --> 00:49:06,809
tell you in a second why surfing on this

1245
00:49:15,680 --> 00:49:12,329
thing long-duration gamma-ray bursts do

1246
00:49:17,839 --> 00:49:15,690
not sound fun but go ahead go back a

1247
00:49:20,269 --> 00:49:17,849
couple of models out there and in terms

1248
00:49:22,309 --> 00:49:20,279
of what it can can happen but what

1249
00:49:25,130 --> 00:49:22,319
observations suggest nowadays is that

1250
00:49:26,930 --> 00:49:25,140
there is a correlation between massive

1251
00:49:29,420 --> 00:49:26,940
stars exploding and slow innovation

1252
00:49:31,759 --> 00:49:29,430
gamma-ray bursts and one favor or one

1253
00:49:34,160 --> 00:49:31,769
popular model is the so-called collapse

1254
00:49:37,579 --> 00:49:34,170
a model and the interior of the star

1255
00:49:39,019 --> 00:49:37,589
gave to a collapse are exactly so we

1256
00:49:41,539 --> 00:49:39,029
have to think of now the interior of the

1257
00:49:45,410 --> 00:49:41,549
star rapidly rotating so it's really a

1258
00:49:47,420 --> 00:49:45,420
and a ball of gas that is rotating

1259
00:49:49,400 --> 00:49:47,430
extremely quickly and now it's going to

1260
00:49:51,380 --> 00:49:49,410
collapse in the usual way as a coral of

1261
00:49:53,420 --> 00:49:51,390
supernova would do so is speaking maybe

1262
00:49:56,690 --> 00:49:53,430
of kind of intermediate masters in in

1263
00:49:58,910 --> 00:49:56,700

general here and if the star was

1264
00:50:00,410 --> 00:49:58,920
internally rotating quick enough then

1265
00:50:02,690 --> 00:50:00,420
you can form an accretion disk around

1266
00:50:05,539 --> 00:50:02,700
this collapsing core so you're producing

1267
00:50:07,279 --> 00:50:05,549
a black hole in the star and while we're

1268
00:50:09,680 --> 00:50:07,289
producing this black hole the outside

1269
00:50:11,900 --> 00:50:09,690
exterior part of the star the envelope

1270
00:50:13,009 --> 00:50:11,910
they still have noticed that and you

1271
00:50:15,079 --> 00:50:13,019
form a black hole or with an accretion

1272
00:50:16,910 --> 00:50:15,089
disk and form a sufficient is you can

1273
00:50:18,620 --> 00:50:16,920
launch a jet and this jet can then

1274
00:50:19,339 --> 00:50:18,630
explore the whole star I think that's

1275
00:50:22,490 --> 00:50:19,349
pretty cool

1276
00:50:24,499 --> 00:50:22,500
that is very cool sounds a little bit

1277
00:50:26,480 --> 00:50:24,509
wildly coyote too because the black hole

1278
00:50:27,980 --> 00:50:26,490
arms but the rest of star doesn't notice

1279
00:50:29,329 --> 00:50:27,990
yet it's kind of like when the koala

1280
00:50:31,549 --> 00:50:29,339
coyote gets out and walks out on the

1281
00:50:33,049 --> 00:50:31,559
over though the cliff and doesn't notice

1282
00:50:36,859 --> 00:50:33,059
and then when he does known as he falls

1283
00:50:38,720 --> 00:50:36,869
so it sounds like that a lot okay it's

1284
00:50:40,700 --> 00:50:38,730
really cool okay well alright so we've

1285
00:50:43,099 --> 00:50:40,710
got core-collapse supernova we've got

1286
00:50:46,940 --> 00:50:43,109
pair-instability supernova long-duration

1287
00:50:48,529 --> 00:50:46,950
gamma-ray burst and we've already seen

1288
00:50:51,849 --> 00:50:48,539

that these things are rotating that we

1289
00:50:55,009 --> 00:50:51,859
have lots of binary components to it

1290
00:50:56,870 --> 00:50:55,019
what about what about binary black holes

1291
00:50:58,099 --> 00:50:56,880
would those get forms and Selma maybe

1292
00:51:04,080 --> 00:50:58,109
you could give us some comments on that

1293
00:51:09,730 --> 00:51:07,000
yeah so a couple of weeks ago of course

1294
00:51:13,450 --> 00:51:09,740
entire astronomy and physics was on its

1295
00:51:16,510 --> 00:51:13,460
head for the news of LIGO had found two

1296
00:51:19,120 --> 00:51:16,520
massive black holes massive 30 times as

1297
00:51:20,710 --> 00:51:19,130
massive at the Sun so we also he didn't

1298
00:51:22,630 --> 00:51:20,720
know that those are forming we had never

1299
00:51:24,100 --> 00:51:22,640
seen a 30 solar mass black hole we had

1300
00:51:27,820 --> 00:51:24,110
never seen a single black hole

1301
00:51:29,860 --> 00:51:27,830
we only know like boring black holes and

1302
00:51:32,200 --> 00:51:29,870
so we were extremely surprised they were

1303
00:51:34,480 --> 00:51:32,210
so massive and so it's two ideas how you

1304
00:51:36,820 --> 00:51:34,490
can make them and one involves a dense

1305
00:51:39,790 --> 00:51:36,830
star cluster something like r136

1306
00:51:42,010 --> 00:51:39,800
and the other idea involves a binary

1307
00:51:44,530 --> 00:51:42,020
system that has a special way of keeping

1308
00:51:47,020 --> 00:51:44,540
the stars together when they die and

1309
00:51:49,000 --> 00:51:47,030
make two black holes some some different

1310
00:51:50,920 --> 00:51:49,010
flavors do this and so now we're looking

1311
00:51:55,090 --> 00:51:50,930
at the star cluster we could do both

1312
00:51:56,170 --> 00:51:55,100
things in this one region right and so

1313
00:51:57,520 --> 00:51:56,180

it's very nice that the metallicity

1314
00:51:59,080 --> 00:51:57,530
talks a little bit about it that the

1315
00:52:01,840 --> 00:51:59,090
Middle East is a little bit lower so we

1316
00:52:04,660 --> 00:52:01,850
think that that helps for these stars to

1317
00:52:06,400 --> 00:52:04,670
not blow off to of too much mast and so

1318
00:52:08,920 --> 00:52:06,410
they actually can stay very massive and

1319
00:52:10,750 --> 00:52:08,930
maybe make pretty massive black holes so

1320
00:52:12,370 --> 00:52:10,760
maybe it was a cluster like this cluster

1321
00:52:15,400 --> 00:52:12,380
that made the two black holes that we

1322
00:52:18,520 --> 00:52:15,410
recently saw I mean I should say he

1323
00:52:20,770 --> 00:52:18,530
heard coalescing right it's the chirp I

1324
00:52:25,900 --> 00:52:20,780
don't know if you have seen the sound

1325
00:52:29,760 --> 00:52:25,910
movies they whoop yeah anyway so uh so

1326
00:52:32,020 --> 00:52:29,770
studies like this pole Crowder and his

1327
00:52:34,060 --> 00:52:32,030
expose dock and our all the

1328
00:52:35,770 --> 00:52:34,070
collaborators we're further examining

1329
00:52:37,150 --> 00:52:35,780
all the other stars in the star clusters

1330
00:52:38,680 --> 00:52:37,160
are we trying to understand better how

1331
00:52:40,420 --> 00:52:38,690
these stars live their life and

1332
00:52:42,490 --> 00:52:40,430
eventually as Fabien explained how they

1333
00:52:43,930 --> 00:52:42,500
die and what kind of black holes they

1334
00:52:45,550 --> 00:52:43,940
make and it's one of the big questions

1335
00:52:47,710 --> 00:52:45,560
we're trying to address here and Hubble

1336
00:52:49,690 --> 00:52:47,720
is has been amazing there to help out I

1337
00:52:51,400 --> 00:52:49,700
know it's it's it's just astonishing to

1338
00:52:52,870 --> 00:52:51,410

think about the idea that now we've got

1339
00:52:55,780 --> 00:52:52,880
the ability to detect gravitational

1340
00:52:57,970 --> 00:52:55,790
waves maybe this would be a sounds to me

1341
00:52:59,770 --> 00:52:57,980
like a pretty good target this this this

1342
00:53:02,320 --> 00:52:59,780
neighboring galaxies to take a look and

1343
00:53:05,230 --> 00:53:02,330
see what might come out of that most of

1344
00:53:07,630 --> 00:53:05,240
the stars are they still there in this

1345
00:53:09,730 --> 00:53:07,640
coming by that I mean have many is there

1346
00:53:12,160 --> 00:53:09,740
a way to know how many have died or

1347
00:53:13,780 --> 00:53:12,170
where we are in this whole evolution of

1348
00:53:14,800 --> 00:53:13,790
the star forming region so these stars

1349
00:53:18,130 --> 00:53:14,810
are still too young

1350
00:53:20,140 --> 00:53:18,140
we may be possibly one has made a black

1351
00:53:21,730 --> 00:53:20,150
hole already but we don't think so

1352
00:53:23,740 --> 00:53:21,740
it is this particularly since probably

1353
00:53:24,940 --> 00:53:23,750
too young and then as soon as you make

1354
00:53:27,100 --> 00:53:24,950
the black hole you still have to wait

1355
00:53:29,950 --> 00:53:27,110
for an extremely long time for the two

1356
00:53:31,300 --> 00:53:29,960
black holes to come together so they are

1357
00:53:33,100 --> 00:53:31,310
if you would have two black holes in a

1358
00:53:34,900 --> 00:53:33,110
binary it takes a long long time for

1359
00:53:36,790 --> 00:53:34,910
gravitational waves to slowly move them

1360
00:53:39,010 --> 00:53:36,800
together it would take Giga years and

1361
00:53:40,900 --> 00:53:39,020
then the last moment the gravitational

1362
00:53:43,090 --> 00:53:40,910
waves become very strong and that's when

1363
00:53:46,300 --> 00:53:43,100

we can listen teresting at the very end

1364
00:53:49,060 --> 00:53:46,310
I guess for this one we're not gonna we

1365
00:53:50,710 --> 00:53:49,070
got not gonna hear binary black hole

1366
00:53:52,480 --> 00:53:50,720
merger from this particular cluster but

1367
00:53:54,250 --> 00:53:52,490
we might hear from something from a

1368
00:53:56,560 --> 00:53:54,260
cluster that is like this one but that

1369
00:54:02,440 --> 00:53:56,570
is a bit further out in the universe and

1370
00:54:04,830 --> 00:54:02,450
it had time to wait so okay so here he

1371
00:54:07,630 --> 00:54:04,840
is a question from Karnak crux from

1372
00:54:09,880 --> 00:54:07,640
YouTube I wonder if James Webb will have

1373
00:54:12,520 --> 00:54:09,890
enough resolution to resolve the

1374
00:54:15,700 --> 00:54:12,530
population three first light stars and

1375
00:54:17,290 --> 00:54:15,710
the answer to that is yes it will and

1376
00:54:20,980 --> 00:54:17,300
I've talked to Massimo Steve Elia about

1377
00:54:23,110 --> 00:54:20,990
this a lot he's the JWST mission head at

1378
00:54:25,030 --> 00:54:23,120
the at the Institute and he was

1379
00:54:26,230 --> 00:54:25,040
explaining a lot about these stars and

1380
00:54:29,080 --> 00:54:26,240
what they're hoping to learn from James

1381
00:54:30,850 --> 00:54:29,090
Webb so the answer to that is yes and

1382
00:54:33,460 --> 00:54:30,860
they will hopefully teach us a lot about

1383
00:54:35,950 --> 00:54:33,470
stars like these but obviously a lot

1384
00:54:37,450 --> 00:54:35,960
less lower in metal content and probably

1385
00:54:38,580 --> 00:54:37,460
a lot smaller from the sounds of what

1386
00:54:42,520 --> 00:54:38,590
I'm hearing today

1387
00:54:44,590 --> 00:54:42,530
Barbara Kyle Cova is asking do you think

1388
00:54:47,170 --> 00:54:44,600

that if the vampire star consumes

1389
00:54:50,320 --> 00:54:47,180
another Stars mass does it get bigger

1390
00:54:53,230 --> 00:54:50,330
and if so when it confused astronomers

1391
00:54:56,260 --> 00:54:53,240
because when calculating its age because

1392
00:54:58,090 --> 00:54:56,270
it depends also on its size wants to

1393
00:55:00,640 --> 00:54:58,100
take that one yeah exactly

1394
00:55:03,280 --> 00:55:00,650
so yeah together with fabric we have

1395
00:55:05,230 --> 00:55:03,290
been writing papers on this so these

1396
00:55:07,630 --> 00:55:05,240
blue stragglers if they eat mass from

1397
00:55:10,000 --> 00:55:07,640
the other star we really like vampire

1398
00:55:12,280 --> 00:55:10,010
stars they kind of get new fuel from the

1399
00:55:14,680 --> 00:55:12,290
other star and that rejuvenates them it

1400
00:55:16,660 --> 00:55:14,690
makes them younger right and so if we

1401
00:55:19,690 --> 00:55:16,670
see these stars we would think they're

1402
00:55:21,220 --> 00:55:19,700
younger than they really are and so now

1403
00:55:23,200 --> 00:55:21,230
this whole clusters were young so it's a

1404
00:55:25,780 --> 00:55:23,210
bit hard to tell but these most massive

1405
00:55:28,120 --> 00:55:25,790
stars they're they're incredibly blue

1406
00:55:30,250 --> 00:55:28,130
and if they

1407
00:55:32,620 --> 00:55:30,260
be bit over we you would expect them to

1408
00:55:34,180 --> 00:55:32,630
be a little rather it's hard to tell for

1409
00:55:35,530 --> 00:55:34,190
this cluster but for clusters like this

1410
00:55:37,090 --> 00:55:35,540
we've seen that the most massive stars

1411
00:55:39,220 --> 00:55:37,100
are definitely younger than the other

1412
00:55:40,690 --> 00:55:39,230
stars and so if you would match the age

1413
00:55:42,370 --> 00:55:40,700

of that star cluster from the most

1414
00:55:43,240 --> 00:55:42,380
massive stars you act yeah you are

1415
00:55:44,950 --> 00:55:43,250
confused you

1416
00:55:48,280 --> 00:55:44,960
you think it's younger than it release

1417
00:55:50,020 --> 00:55:48,290
it's like there's a way to beat it it's

1418
00:55:51,640 --> 00:55:50,030
a facelift for the cluster yeah there's

1419
00:55:55,000 --> 00:55:51,650
many ways for you to pretend you're

1420
00:55:58,960 --> 00:55:55,010
younger but you know just for men and

1421
00:56:01,210 --> 00:55:58,970
your goatee might help - oh no I okay so

1422
00:56:01,830 --> 00:56:01,220
you look sophisticated in the House of

1423
00:56:04,960 --> 00:56:01,840
Lords

1424
00:56:09,550 --> 00:56:04,970
thank you okay well let's go - so while

1425
00:56:11,860 --> 00:56:09,560
I've got you here Scott what about

1426
00:56:15,580 --> 00:56:11,870
Twitter at all are we getting any other

1427
00:56:17,560 --> 00:56:15,590
Tweety files from the Tweety pies but we

1428
00:56:19,750 --> 00:56:17,570
are having lots of activity on on

1429
00:56:21,850 --> 00:56:19,760
Twitter especially as people just really

1430
00:56:26,170 --> 00:56:21,860
loving the the graphics that you guys

1431
00:56:28,060 --> 00:56:26,180
created from ESO the the images that

1432
00:56:31,870 --> 00:56:28,070
we've released from Hubble and the pie

1433
00:56:34,690 --> 00:56:31,880
chart was lovely as well yes ah yes so

1434
00:56:36,460 --> 00:56:34,700
that pie charts awesome and as well as

1435
00:56:38,410 --> 00:56:36,470
what I really loved and I'm seeing a lot

1436
00:56:40,450 --> 00:56:38,420
of conversation about is from the

1437
00:56:42,670 --> 00:56:40,460
comparison between the red dwarf the

1438
00:56:45,820 --> 00:56:42,680

yellow dwarf like our son a blue dwarf

1439
00:56:48,550 --> 00:56:45,830
and then just how much those are dwarfed

1440
00:56:49,630 --> 00:56:48,560
by our 136 oh that's like Paul calls

1441
00:56:51,250 --> 00:56:49,640
everything at dwarf I don't remember

1442
00:56:53,110 --> 00:56:51,260
calling I don't remember hearing a

1443
00:56:54,850 --> 00:56:53,120
yellow dwarf or a blue dwarf until I saw

1444
00:56:58,570 --> 00:56:54,860
that things because everything is dwarf

1445
00:57:00,760 --> 00:56:58,580
to that when that's what you're used to

1446
00:57:02,830 --> 00:57:00,770
working with I guess so alright you know

1447
00:57:07,210 --> 00:57:02,840
it is everything's tiny you know it's

1448
00:57:09,280 --> 00:57:07,220
all perspective okay well so what's so

1449
00:57:10,930 --> 00:57:09,290
what's next for you guys so you've got

1450
00:57:11,830 --> 00:57:10,940
these observations in are you going to

1451
00:57:14,200 --> 00:57:11,840
be follow doing some follow-up

1452
00:57:16,000 --> 00:57:14,210
observations with this cluster are you

1453
00:57:17,680 --> 00:57:16,010
looking at other clusters and I'll have

1454
00:57:19,390 --> 00:57:17,690
maybe maybe Fabian you can give us some

1455
00:57:21,910 --> 00:57:19,400
idea what's what's next for you guys I

1456
00:57:25,510 --> 00:57:21,920
would probably like to pass a credit

1457
00:57:27,220 --> 00:57:25,520
report because he's still sitting about

1458
00:57:29,530 --> 00:57:27,230
this particular cluster and even even

1459
00:57:33,700 --> 00:57:29,540
more so good so once you tell us what's

1460
00:57:35,440 --> 00:57:33,710
next for yes published the study of your

1461
00:57:36,700 --> 00:57:35,450
father Neil G violet and we're now

1462
00:57:38,350 --> 00:57:36,710
working through some optical

1463
00:57:41,140 --> 00:57:38,360

observations we've taken with Hubble

1464
00:57:41,440 --> 00:57:41,150
face and looking at the looking looking

1465
00:57:43,839 --> 00:57:41,450
for

1466
00:57:46,270 --> 00:57:43,849
is amongst the stars in the cluster

1467
00:57:48,040 --> 00:57:46,280
we're looking for how fast the stars are

1468
00:57:50,200 --> 00:57:48,050
rotating now give us a clue as to

1469
00:57:55,630 --> 00:57:50,210
whether they they've been spun up it's

1470
00:57:57,190 --> 00:57:55,640
really spam pyre mass exchange and

1471
00:57:59,890 --> 00:57:57,200
actually with with summer we're also

1472
00:58:02,500 --> 00:57:59,900
looking at with huh ball in ships this

1473
00:58:04,060 --> 00:58:02,510
has a exquisite angular resolution to be

1474
00:58:05,770 --> 00:58:04,070
able to resolve these stars we should

1475
00:58:07,210 --> 00:58:05,780
look very close together but there's

1476
00:58:10,060 --> 00:58:07,220
actually other instrument on Hubble

1477
00:58:13,210 --> 00:58:10,070
called fgs and that can actually go a

1478
00:58:15,490 --> 00:58:13,220
factor of factor of 10 better in angular

1479
00:58:17,550 --> 00:58:15,500
resolution so with Selma and my postdoc

1480
00:58:20,800 --> 00:58:17,560
we're looking at trying to look for

1481
00:58:23,319 --> 00:58:20,810
faint companions it's a much closer

1482
00:58:26,680 --> 00:58:23,329
separation than we can do with the kind

1483
00:58:29,650 --> 00:58:26,690
of conventional imaging approach so the

1484
00:58:32,950 --> 00:58:29,660
supercar loop the thing is there isn't

1485
00:58:34,710 --> 00:58:32,960
anything quite as impressive or more

1486
00:58:37,359 --> 00:58:34,720
impressive than our 36

1487
00:58:39,940 --> 00:58:37,369
within our galaxies this nothing is

1488
00:58:42,579 --> 00:58:39,950

impressive in Andromeda or in the

1489
00:58:45,520 --> 00:58:42,589
triangular member 3 and so you've got to

1490
00:58:47,170 --> 00:58:45,530
go quite a lot further away to find more

1491
00:58:49,990 --> 00:58:47,180
impressive star clusters than this one

1492
00:58:52,569 --> 00:58:50,000
and so really I think that the next for

1493
00:58:54,250 --> 00:58:52,579
the next in a while is to really get the

1494
00:58:58,210 --> 00:58:54,260
most out of this cluster to look for

1495
00:59:00,190 --> 00:58:58,220
look for binaries look for to figure

1496
00:59:03,099 --> 00:59:00,200
this as much as we can it's really great

1497
00:59:04,870 --> 00:59:03,109
it's such an amazing stellar nursery is

1498
00:59:07,510 --> 00:59:04,880
so close by for you to be able to study

1499
00:59:08,740 --> 00:59:07,520
that's really good so cool all right

1500
00:59:10,480 --> 00:59:08,750
well we'll look forward to hearing more

1501
00:59:14,079 --> 00:59:10,490
from you guys in your press releases and

1502
00:59:17,079 --> 00:59:14,089
your paper so thank you guys for joining

1503
00:59:18,819 --> 00:59:17,089
us so on behalf of Paul Crowther baby

1504
00:59:20,140 --> 00:59:18,829
and Schneider and so I'm gonna mink I

1505
00:59:21,849 --> 00:59:20,150
want to thank you and thank my guests

1506
00:59:24,760 --> 00:59:21,859
for showing up taking time out of their

1507
00:59:26,680 --> 00:59:24,770
day to explain there's awesome science

1508
00:59:29,050 --> 00:59:26,690
and the going on in the Large Magellanic

1509
00:59:32,290 --> 00:59:29,060
Cloud with the youngest or some of the

1510
00:59:34,780 --> 00:59:32,300
most massive stars in the known universe

1511
00:59:36,520 --> 00:59:34,790
writing next door right over there next

1512
00:59:38,950 --> 00:59:36,530
to Scotts house so that's where I don't

1513
00:59:42,370 --> 00:59:38,960

from my house if you know it's kind of a

1514
00:59:45,130 --> 00:59:42,380
big deal out here yeah I do want to

1515
00:59:46,510 --> 00:59:45,140
learn a lot more questions out there I'm

1516
00:59:48,309 --> 00:59:46,520
sorry we have many and we'll answer them

1517
00:59:50,410 --> 00:59:48,319
but there Ben this is just a fascinating

1518
00:59:52,600 --> 00:59:50,420
topic so well we'll try to do is try to

1519
00:59:54,610 --> 00:59:52,610
hit some of those on Twitter later on

1520
00:59:57,430 --> 00:59:54,620
or in the comments later on YouTube and

1521
00:59:59,200 --> 00:59:57,440
Facebook alright that's it and on behalf

1522
01:00:00,400 --> 00:59:59,210
of Karol Christian I will and Scott

1523
01:00:02,170 --> 01:00:00,410
Lewis I want to thank you all for

1524
01:00:04,750 --> 01:00:02,180
watching we'll be back next week same

1525
01:00:06,850 --> 01:00:04,760
time Thursday 3:00 p.m. Eastern I don't

1526
01:00:09,700 --> 01:00:06,860
know what the topic is because Carol

1527
01:00:12,460 --> 01:00:09,710
does that and so she'll tell us what you

1528
01:00:13,930 --> 01:00:12,470
drink what we talking about but we will

1529
01:00:15,370 --> 01:00:13,940
be back so hope you guys can tune in if

1530
01:00:16,450 --> 01:00:15,380
you have not subscribed to Hubble site

1531
01:00:18,070 --> 01:00:16,460
channel please do that

1532
01:00:20,110 --> 01:00:18,080
by clicking on the little subscribe

1533
01:00:23,350 --> 01:00:20,120
button on the channel page also follow

1534
01:00:26,650 --> 01:00:23,360
us on twitter at hubble telescope and as