

1
00:00:00,030 --> 00:00:04,919
nope hello everybody and welcome to this

2
00:00:02,819 --> 00:00:07,740
week's Hubble hangout my name is Tony

3
00:00:04,919 --> 00:00:09,210
Darnell and I am your host for this I

4
00:00:07,740 --> 00:00:10,559
think is one of one of our better

5
00:00:09,210 --> 00:00:11,219
hangouts we got a really exciting one

6
00:00:10,558 --> 00:00:12,808
planned for you

7
00:00:11,218 --> 00:00:14,160
you know I say that but you know every

8
00:00:12,808 --> 00:00:15,570
week they're all great aren't they I

9
00:00:14,160 --> 00:00:17,789
mean I think all of our Hubble hangouts

10
00:00:15,570 --> 00:00:19,528
are awesome so this week we're going to

11
00:00:17,789 --> 00:00:21,900
be talking with astronomers who've used

12
00:00:19,528 --> 00:00:24,268
data from the Kepler space telescope to

13
00:00:21,899 --> 00:00:26,070
discover the precursor of or have

14
00:00:24,268 --> 00:00:28,829
observed for the first time a precursor

15
00:00:26,070 --> 00:00:30,778
of a supernova in Kepler data and we're

16
00:00:28,829 --> 00:00:33,030
going to talk about why that's important

17
00:00:30,778 --> 00:00:35,579
what they did and what kind how they use

18
00:00:33,030 --> 00:00:37,260
the Kepler data itself to to find these

19
00:00:35,579 --> 00:00:39,450
things because this is also something

20
00:00:37,259 --> 00:00:41,609
that is very important in astronomy

21
00:00:39,450 --> 00:00:44,520
these days using archives to do science

22
00:00:41,609 --> 00:00:46,200
and research so an international science

23
00:00:44,520 --> 00:00:48,930
team which is led by dr. Peter garnet

24
00:00:46,200 --> 00:00:52,620
ovitch at the she at the University of

25
00:00:48,929 --> 00:00:54,329
Notre Dame in Indiana they led the team

26
00:00:52,619 --> 00:00:56,669
that captured and analyzed light from

27
00:00:54,329 --> 00:00:59,009
Kepler over a three-year period that

28
00:00:56,670 --> 00:01:01,770
studied 500 distant galaxies searching

29

00:00:59,009 --> 00:01:03,988
some 50 trillion stars and they were

30
00:01:01,770 --> 00:01:06,420
hunting for signs of this stellar death

31
00:01:03,988 --> 00:01:08,340
explosion known as supernovae and I read

32
00:01:06,420 --> 00:01:09,629
that straight from the press release

33
00:01:08,340 --> 00:01:11,040
because I wanted to get it right so

34
00:01:09,629 --> 00:01:15,329
anyway we're going to tell him with

35
00:01:11,040 --> 00:01:18,060
Peter as well as his colleague from

36
00:01:15,329 --> 00:01:19,769
Australia who went through a lot of

37
00:01:18,060 --> 00:01:21,930
trouble to be with us here today so he's

38
00:01:19,769 --> 00:01:25,769
gotten up very early in the morning or

39
00:01:21,930 --> 00:01:27,570
Brad is 5 o'clock in the morning before

40
00:01:25,769 --> 00:01:29,879
I introduce you properly I have to say

41
00:01:27,569 --> 00:01:33,029
hello to my co-host dr. Carol Christian

42
00:01:29,879 --> 00:01:35,009
the HST that's Hubble Space Telescope

43
00:01:33,030 --> 00:01:37,228

for anybody who doesn't know I'll reach

44

00:01:35,009 --> 00:01:37,769

out scientists I Carol it's good to see

45

00:01:37,228 --> 00:01:40,590

you again

46

00:01:37,769 --> 00:01:43,319

hey Tony how are you I'm really good and

47

00:01:40,590 --> 00:01:44,399

also Scott Lewis the he's Hamming all

48

00:01:43,319 --> 00:01:46,438

the social media and driving the

49

00:01:44,399 --> 00:01:48,570

internet and handling our comments and

50

00:01:46,438 --> 00:01:50,008

interacting and posting on social media

51

00:01:48,569 --> 00:01:53,419

so hi Scott it's good to see you how are

52

00:01:50,009 --> 00:01:57,149

you doing I am getting over the plague

53

00:01:53,420 --> 00:01:59,579

thank you big your reasoning out here in

54

00:01:57,149 --> 00:02:02,489

Los Angeles it's underneath space

55

00:01:59,578 --> 00:02:04,618

shuttle Endeavour we had a blast hung

56

00:02:02,489 --> 00:02:06,048

out with Buzz Aldrin and Sam Chris

57

00:02:04,618 --> 00:02:09,449

Bradley

58
00:02:06,049 --> 00:02:11,939
you know he was there also I got to hang

59
00:02:09,449 --> 00:02:16,379
out with Robert Picardo

60
00:02:11,939 --> 00:02:17,939
better known as the doctor yeah but he's

61
00:02:16,379 --> 00:02:19,819
also working with the planet Church

62
00:02:17,939 --> 00:02:22,319
society so we had a really good night

63
00:02:19,819 --> 00:02:27,030
thousands of people there and I got all

64
00:02:22,319 --> 00:02:30,090
their germs so that's worse than being

65
00:02:27,030 --> 00:02:32,430
on an airplane for yeah it's yeah it's

66
00:02:30,090 --> 00:02:37,020
like being at a super super conference

67
00:02:32,430 --> 00:02:38,969
in a very close combined space oh so

68
00:02:37,020 --> 00:02:43,530
that's what space travel would be like

69
00:02:38,969 --> 00:02:47,069
yeah all of all the nerd germs going

70
00:02:43,530 --> 00:02:49,020
around and around and around on jalisa

71
00:02:47,069 --> 00:02:50,459
terms oh geez

72
00:02:49,020 --> 00:02:53,010
well I didn't see some of your Facebook

73
00:02:50,460 --> 00:02:54,750
postings and was okay so I was jealous

74
00:02:53,009 --> 00:02:56,639
but that's okay that's fine all right

75
00:02:54,750 --> 00:03:06,090
it's okay next time I'll call you you

76
00:02:56,639 --> 00:03:08,219
know we we don't have lives we actually

77
00:03:06,090 --> 00:03:08,520
don't have lives but we've gotta lose in

78
00:03:08,219 --> 00:03:11,639
LA

79
00:03:08,520 --> 00:03:14,430
is it you know I'm just but it was for

80
00:03:11,639 --> 00:03:17,339
science so they're also with my JPL

81
00:03:14,430 --> 00:03:19,770
friends so way to boost their up there

82
00:03:17,340 --> 00:03:22,590
so it was great we had a lot of fun

83
00:03:19,770 --> 00:03:25,280
doing science but also partying in

84
00:03:22,590 --> 00:03:28,409
apparently that's the part I saw but I

85
00:03:25,280 --> 00:03:35,490
mean let's be honest here we all know

86

00:03:28,409 --> 00:03:37,889
what competition well this particular

87
00:03:35,490 --> 00:03:39,800
Yuri's Night was kind of kind of a big

88
00:03:37,889 --> 00:03:42,449
one anyway because you guys saw that

89
00:03:39,800 --> 00:03:44,630
breakthrough starshot announcement by

90
00:03:42,449 --> 00:03:48,269
that Russian millionaire billionaire

91
00:03:44,629 --> 00:03:52,669
gonna send little tiny probes to us to

92
00:03:48,270 --> 00:03:54,780
stars and and that back yeah here's

93
00:03:52,669 --> 00:03:58,469
Stephen Hawking and everybody and

94
00:03:54,780 --> 00:04:00,390
animate made kind of a big splash so I

95
00:03:58,469 --> 00:04:02,430
don't know I didn't see that coming that

96
00:04:00,389 --> 00:04:03,809
sort of came out of nowhere for me so I

97
00:04:02,430 --> 00:04:09,800
don't know I don't know anything about

98
00:04:03,810 --> 00:04:09,800
this and it's actually going nowhere but

99
00:04:14,990 --> 00:04:20,340
yeah really seriously we can probably

100
00:04:18,810 --> 00:04:25,470

think of other stuff to do with that

101

00:04:20,339 --> 00:04:25,829

money but whatever okay so onto Kepler

102

00:04:25,470 --> 00:04:28,380

so

103

00:04:25,829 --> 00:04:30,959

we want the whole point of these

104

00:04:28,379 --> 00:04:33,598

hangouts folks is to bring the latest

105

00:04:30,959 --> 00:04:36,448

science from Hubble and its sister

106

00:04:33,598 --> 00:04:37,740

missions to you directly and you can

107

00:04:36,449 --> 00:04:39,270

interact and talk with some of the

108

00:04:37,740 --> 00:04:40,978

science some of the scientists who are

109

00:04:39,269 --> 00:04:43,198

doing the research so we want your

110

00:04:40,978 --> 00:04:44,879

questions we want your comments and so

111

00:04:43,199 --> 00:04:46,288

we hope you'll take some time during

112

00:04:44,879 --> 00:04:48,598

this hangout to share with us your

113

00:04:46,288 --> 00:04:50,490

feelings your questions and we'll get to

114

00:04:48,598 --> 00:04:52,259

them but but you need to know how so

115
00:04:50,490 --> 00:04:54,418
Scott why don't you tell people how they

116
00:04:52,259 --> 00:04:55,860
can interact with us well the best way

117
00:04:54,418 --> 00:04:57,750
to interact with us is where I'm seeing

118
00:04:55,860 --> 00:04:59,970
a bunch of people already is in the

119
00:04:57,750 --> 00:05:02,970
YouTube live chat so since we're using

120
00:04:59,970 --> 00:05:04,860
the YouTube live event you can interact

121
00:05:02,970 --> 00:05:06,240
with other people watching the show as

122
00:05:04,860 --> 00:05:07,770
we're doing it live you can ask

123
00:05:06,240 --> 00:05:10,769
questions and I'll be going through

124
00:05:07,769 --> 00:05:13,049
there locking people if I need to which

125
00:05:10,769 --> 00:05:17,399
unfortunately I have so let's try to

126
00:05:13,050 --> 00:05:19,860
keep it on topic but ask us some

127
00:05:17,399 --> 00:05:21,568
questions regarding the the data on on

128
00:05:19,860 --> 00:05:24,120
this Hubble hangout or anything

129
00:05:21,569 --> 00:05:26,759
regarding what we're talking about here

130
00:05:24,120 --> 00:05:29,250
with detecting the the supernova also

131
00:05:26,759 --> 00:05:31,259
we're having the conversation over on

132
00:05:29,250 --> 00:05:33,990
twitter using the hashtag Hubble hangout

133
00:05:31,259 --> 00:05:36,479
so I am live tweeting will be sharing

134
00:05:33,990 --> 00:05:38,250
out some of the imagery and the graphics

135
00:05:36,478 --> 00:05:40,319
that go along with today's hangout any

136
00:05:38,250 --> 00:05:42,930
questions use that hashtag and we'll get

137
00:05:40,319 --> 00:05:45,120
back to you other ways to is we have the

138
00:05:42,930 --> 00:05:47,459
event so opened on Facebook and Google+

139
00:05:45,120 --> 00:05:48,750
so if you do have comments there I will

140
00:05:47,459 --> 00:05:50,638
be going through and taking a look at

141
00:05:48,750 --> 00:05:52,829
them but the the best and easiest way is

142
00:05:50,639 --> 00:05:55,889
on Twitter and directly here on YouTube

143

00:05:52,829 --> 00:06:05,788
uh Scott I just want to say I'm really

144
00:05:55,889 --> 00:06:07,740
glad you know if you need to make a

145
00:06:05,788 --> 00:06:09,598
last-minute phone call late at night is

146
00:06:07,740 --> 00:06:15,150
a three-hour time difference between you

147
00:06:09,598 --> 00:06:16,439
and me I'm still awake alright so yes

148
00:06:15,149 --> 00:06:19,019
and what will happen is Scott's really

149
00:06:16,439 --> 00:06:21,060
good about posting all the relevant

150
00:06:19,019 --> 00:06:23,008
things into a this chat window that we

151
00:06:21,060 --> 00:06:24,478
can see that helps me to get to your

152
00:06:23,009 --> 00:06:26,729
comments so we will get to all of them

153
00:06:24,478 --> 00:06:28,439
as soon as there is if that when there's

154
00:06:26,728 --> 00:06:30,240
time and so please let us have it

155
00:06:28,439 --> 00:06:31,949
bring it on we want to see it so let me

156
00:06:30,240 --> 00:06:33,870
introduce our guests today these are a

157
00:06:31,949 --> 00:06:35,699

couple of astronomers who have been

158

00:06:33,870 --> 00:06:39,509

combing through Kepler data oh I have

159

00:06:35,699 --> 00:06:43,139

with me dr. dr. Peter Gunn

160

00:06:39,509 --> 00:06:44,579

bitch and he is he's the like I said an

161

00:06:43,139 --> 00:06:46,229

astrophysics professor at the University

162

00:06:44,579 --> 00:06:49,169

of Notre Dame and we went through this

163

00:06:46,230 --> 00:06:51,330

also joining me is dr. Brad Tucker he is

164

00:06:49,170 --> 00:06:54,030

a I forgot to ask you before we started

165

00:06:51,329 --> 00:06:56,609

are you a postdoc an associate professor

166

00:06:54,029 --> 00:06:58,619

what are you doing Don I'm a research

167

00:06:56,610 --> 00:07:00,350

fellow Australia you just kind of do

168

00:06:58,620 --> 00:07:04,259

science until you get a permanent job

169

00:07:00,350 --> 00:07:06,770

okay the science you weren't down in

170

00:07:04,259 --> 00:07:06,769

Australia

171

00:07:10,350 --> 00:07:14,129

oh and I just want to give a shout out

172
00:07:12,029 --> 00:07:16,279
to Notre Dame my brother went to Notre

173
00:07:14,129 --> 00:07:16,279
Dame

174
00:07:20,660 --> 00:07:29,220
I know it's Notre Dame and I'm not even

175
00:07:25,819 --> 00:07:48,659
I'm not gonna show you that green stuff

176
00:07:29,220 --> 00:07:55,020
I have everywhere Notre Dame that means

177
00:07:48,660 --> 00:07:56,280
right Notre Dame okay so so so Peter

178
00:07:55,019 --> 00:07:57,509
let's start with you give us some a

179
00:07:56,279 --> 00:08:00,089
little background on what you were

180
00:07:57,509 --> 00:08:01,680
trying to do what your what your main

181
00:08:00,089 --> 00:08:06,899
interest was studying in and what you

182
00:08:01,680 --> 00:08:09,930
found using Kepler data so Kepler really

183
00:08:06,899 --> 00:08:12,449
was designed to look for planets so it

184
00:08:09,930 --> 00:08:14,850
would focus on stars in our galaxy and

185
00:08:12,449 --> 00:08:18,389
look for little dips as planets went in

186
00:08:14,850 --> 00:08:21,120
front but it focused on about a hundred

187
00:08:18,389 --> 00:08:23,729
square degrees on the sky and people who

188
00:08:21,120 --> 00:08:25,560
study supernovas like Brad and I thought

189
00:08:23,730 --> 00:08:27,900
you know there are galaxies in that

190
00:08:25,560 --> 00:08:31,319
field as well and we can look at those

191
00:08:27,899 --> 00:08:34,079
galaxies and just wait and hope that a

192
00:08:31,319 --> 00:08:36,418
supernova will go off and our initial

193
00:08:34,080 --> 00:08:39,389
proposals were kind of modest we we

194
00:08:36,418 --> 00:08:43,079
asked for about a hundred galaxies to

195
00:08:39,389 --> 00:08:45,600
follow and then rule of thumb is you get

196
00:08:43,080 --> 00:08:47,430
a bout of supernovae every hundred years

197
00:08:45,600 --> 00:08:50,180
in a galaxy so we thought we would get

198
00:08:47,429 --> 00:08:51,809
me one supernova per year in our

199
00:08:50,179 --> 00:08:54,120
proposals

200

00:08:51,809 --> 00:08:55,409
so I have a quote I have a question

201
00:08:54,120 --> 00:08:59,100
because I remember because we have the

202
00:08:55,409 --> 00:09:02,219
archived data for Kepler so initially

203
00:08:59,100 --> 00:09:05,189
that opportunity was not open to the

204
00:09:02,220 --> 00:09:08,339
community right so at first that that

205
00:09:05,188 --> 00:09:10,078
and then there was a Geo program or

206
00:09:08,339 --> 00:09:13,019
something and then at that time you

207
00:09:10,078 --> 00:09:15,568
could request specific things to look at

208
00:09:13,019 --> 00:09:18,778
is that how it worked yeah so I think by

209
00:09:15,568 --> 00:09:20,578
the second cycle there was a Geo program

210
00:09:18,778 --> 00:09:23,129
and we could we could ask for whatever

211
00:09:20,578 --> 00:09:25,948
pixels were remaining because although

212
00:09:23,129 --> 00:09:26,970
it has a hundred square degree field the

213
00:09:25,948 --> 00:09:29,639
number of pixels that can actually

214
00:09:26,970 --> 00:09:32,249

download and send to the earth is is

215

00:09:29,639 --> 00:09:34,379

much much smaller than that so it's real

216

00:09:32,249 --> 00:09:36,120

that's right and so they had picked out

217

00:09:34,379 --> 00:09:38,639

the stars they wanted to monitor and

218

00:09:36,120 --> 00:09:40,470

then they said okay now you some of you

219

00:09:38,639 --> 00:09:45,209

can have the other pixels right there

220

00:09:40,470 --> 00:09:47,100

are like a thousand other stars or other

221

00:09:45,208 --> 00:09:47,758

objects you could you could download as

222

00:09:47,100 --> 00:09:51,540

well

223

00:09:47,759 --> 00:09:54,449

there was a competitive okay call for

224

00:09:51,539 --> 00:09:59,578

that and and so we put in a proposal and

225

00:09:54,448 --> 00:10:02,250

we got our hundred galaxies and so in

226

00:09:59,578 --> 00:10:05,188

parallel and unknown to us Brad and I

227

00:10:02,250 --> 00:10:06,360

were on this original proposal there was

228

00:10:05,188 --> 00:10:09,179

a group at the University of Maryland

229
00:10:06,360 --> 00:10:11,659
that was interested in a GN active

230
00:10:09,179 --> 00:10:14,638
galactic nuclei these are accreting

231
00:10:11,659 --> 00:10:16,980
supermassive black holes and they

232
00:10:14,639 --> 00:10:19,188
produced variability in the cores of

233
00:10:16,980 --> 00:10:21,990
galaxies and they wanted to study this

234
00:10:19,188 --> 00:10:24,870
with with Kepler so they actually put in

235
00:10:21,990 --> 00:10:27,149
four times more galaxies and we did we

236
00:10:24,870 --> 00:10:28,948
were kind of a little tentative and they

237
00:10:27,149 --> 00:10:32,009
thought all this go all out and we'll do

238
00:10:28,948 --> 00:10:34,859
400 galaxies so in the end we combined

239
00:10:32,009 --> 00:10:37,199
all our galaxies together and they ended

240
00:10:34,860 --> 00:10:39,000
up finding supernovae in their galaxies

241
00:10:37,198 --> 00:10:41,750
we didn't find any supernovae in our

242
00:10:39,000 --> 00:10:45,240
galaxies but it all worked out well we

243
00:10:41,750 --> 00:10:49,980
collaborated on this whole thing and not

244
00:10:45,240 --> 00:10:51,120
only are we having these core collapse

245
00:10:49,980 --> 00:10:53,730
supernovae that we're talking about

246
00:10:51,120 --> 00:10:55,799
today but we had three type 1a

247
00:10:53,730 --> 00:10:59,519
supernovae thermonuclear explosions that

248
00:10:55,799 --> 00:11:02,188
we we published last year so we actually

249
00:10:59,519 --> 00:11:03,600
have tons of supernovas then type 1 i:r

250
00:11:02,188 --> 00:11:04,919
these standard candles we've talked

251
00:11:03,600 --> 00:11:06,629
about many times before

252
00:11:04,919 --> 00:11:08,519
and other hangouts well I just want to

253
00:11:06,629 --> 00:11:11,250
point out though that what one of the

254
00:11:08,519 --> 00:11:14,879
the largest benefits and one of the

255
00:11:11,250 --> 00:11:18,389
biggest things that Kepler data gives us

256
00:11:14,879 --> 00:11:20,939
is this time sequence of observations

257

00:11:18,389 --> 00:11:22,409
one of the because it looks in only one

258
00:11:20,940 --> 00:11:24,660
area of the sky this is toward the

259
00:11:22,409 --> 00:11:27,838
constellation Cygnus and studying these

260
00:11:24,659 --> 00:11:29,009
stars 160,000 some oddities and careless

261
00:11:27,839 --> 00:11:31,290
pointed this out another hangouts and

262
00:11:29,009 --> 00:11:33,120
another venues where you need a time

263
00:11:31,289 --> 00:11:35,490
series of the same you need a lot of

264
00:11:33,120 --> 00:11:37,528
observations of the same thing to

265
00:11:35,490 --> 00:11:38,970
capture these dips and brightness as the

266
00:11:37,528 --> 00:11:41,698
planet moves in front of its host star

267
00:11:38,970 --> 00:11:43,889
but that and as Peter just pointed out

268
00:11:41,698 --> 00:11:46,409
we can also that lends itself to other

269
00:11:43,889 --> 00:11:49,320
kinds of science where you need a lot of

270
00:11:46,409 --> 00:11:51,809
images in sequence and so Kepler takes

271
00:11:49,320 --> 00:11:53,670

and so if there was one blip in

272

00:11:51,809 --> 00:11:57,528
brightness you could write a paper on

273

00:11:53,669 --> 00:12:00,389
that but but we would laugh at you so

274

00:11:57,528 --> 00:12:02,490
you actually have to have it something

275

00:12:00,389 --> 00:12:05,459
you hope that it repeats now some

276

00:12:02,490 --> 00:12:08,009
objects like a supernova I'm gonna

277

00:12:05,458 --> 00:12:09,509
repeat but you have to make sure that as

278

00:12:08,009 --> 00:12:11,669
the observations go that you're looking

279

00:12:09,509 --> 00:12:13,769
at a real phenomenon and it and that's

280

00:12:11,669 --> 00:12:15,990
hard when these things are transient I

281

00:12:13,769 --> 00:12:18,899
mean so that's why we have an archive is

282

00:12:15,990 --> 00:12:20,370
because because we archive the data and

283

00:12:18,899 --> 00:12:23,578
the hope is that people will comb

284

00:12:20,370 --> 00:12:26,220
through that data for a while and and

285

00:12:23,578 --> 00:12:28,439
maybe find other things as well I mean

286
00:12:26,220 --> 00:12:30,269
one of the good examples of the scale of

287
00:12:28,440 --> 00:12:32,760
what Kepler does with this time series

288
00:12:30,269 --> 00:12:35,070
is the five supernovae so these two core

289
00:12:32,759 --> 00:12:37,230
collapse plus the three one A's that

290
00:12:35,070 --> 00:12:39,390
Peter talked about in a previous paper

291
00:12:37,230 --> 00:12:42,300
the the amount of data and the data

292
00:12:39,389 --> 00:12:44,669
points we have in these five are more

293
00:12:42,299 --> 00:12:46,549
than all other supernova observations of

294
00:12:44,669 --> 00:12:49,349
all other supernovae ever observed

295
00:12:46,549 --> 00:12:51,389
that's wrong that's a really good thing

296
00:12:49,350 --> 00:12:53,399
so if you think of all of the thousands

297
00:12:51,389 --> 00:12:54,750
of supernovae we have more data on our

298
00:12:53,399 --> 00:12:56,870
five with Kepler than all of those

299
00:12:54,750 --> 00:12:59,970
because of the time cadence it takes

300
00:12:56,870 --> 00:13:01,889
Nativity 30 minutes right or so that's

301
00:12:59,970 --> 00:13:15,360
when you get a new image so that's right

302
00:13:01,889 --> 00:13:17,399
it actually is also nice because even

303
00:13:15,360 --> 00:13:18,649
though you know every 30 minutes is all

304
00:13:17,399 --> 00:13:21,019
probably a little too much for

305
00:13:18,649 --> 00:13:23,899
something that takes months to go up and

306
00:13:21,019 --> 00:13:27,379
down we can actually average that data

307
00:13:23,899 --> 00:13:32,360
together and improve the quality of any

308
00:13:27,379 --> 00:13:34,550
you know 24-hour observation is the sum

309
00:13:32,360 --> 00:13:36,740
of all these half an hour observation so

310
00:13:34,549 --> 00:13:38,838
we actually can beat the noise down and

311
00:13:36,740 --> 00:13:40,938
observe things fainter than other people

312
00:13:38,839 --> 00:13:42,769
could with Kepler that's right because I

313
00:13:40,938 --> 00:13:44,208
mean you do you need a rapid time

314

00:13:42,769 --> 00:13:46,909
sequence for if you're trying to measure

315
00:13:44,208 --> 00:13:48,378
a light transit or a tri light curve of

316
00:13:46,909 --> 00:13:50,208
a transiting planet that might be close

317
00:13:48,379 --> 00:13:52,039
to a star that might do it in only a few

318
00:13:50,208 --> 00:13:53,539
hours you want to get a lot of data

319
00:13:52,039 --> 00:13:55,759
points but in the case of supernova

320
00:13:53,539 --> 00:13:57,438
studies you can actually add them up and

321
00:13:55,759 --> 00:13:59,808
that's a valuable technique in astronomy

322
00:13:57,438 --> 00:14:02,480
where you can take two different

323
00:13:59,808 --> 00:14:04,909
exposures and add them together and get

324
00:14:02,480 --> 00:14:06,920
an image of that is the sum of like

325
00:14:04,909 --> 00:14:08,419
we've had a two 10-second exposure

326
00:14:06,919 --> 00:14:10,969
exposure image you can add them together

327
00:14:08,419 --> 00:14:13,219
to get a 20 second exposure image but

328
00:14:10,970 --> 00:14:15,259

the noise only goes up as the square

329

00:14:13,220 --> 00:14:18,170

root of two so it you get a lot more

330

00:14:15,259 --> 00:14:20,379

signal versus the noise and it's a very

331

00:14:18,169 --> 00:14:23,958

valuable technique that astronomers use

332

00:14:20,379 --> 00:14:26,480

it's a divergent but but this is a

333

00:14:23,958 --> 00:14:28,878

common technique now is to take a lot

334

00:14:26,480 --> 00:14:31,159

all of the data you haven't stack it and

335

00:14:28,879 --> 00:14:34,308

if you do that then you can do

336

00:14:31,159 --> 00:14:36,139

detections and then what you do is you

337

00:14:34,308 --> 00:14:38,659

go back and you look at the individual

338

00:14:36,139 --> 00:14:41,089

exposures for those detections

339

00:14:38,659 --> 00:14:43,879

and that's in fact a really valuable

340

00:14:41,089 --> 00:14:45,860

technique for transients it's also a

341

00:14:43,879 --> 00:14:47,688

valuable technique for looking at high

342

00:14:45,860 --> 00:14:50,568

redshift objects because you can smush

343
00:14:47,688 --> 00:14:53,028
all the data together you search for all

344
00:14:50,568 --> 00:14:55,039
the objects that that have emitted any

345
00:14:53,028 --> 00:14:57,318
light and then you go back and you

346
00:14:55,039 --> 00:14:59,328
measure each color and you see which

347
00:14:57,318 --> 00:15:01,789
one's emitted in the visible and in the

348
00:14:59,328 --> 00:15:05,058
and thread and this caught in this case

349
00:15:01,789 --> 00:15:07,849
instead of color it's time when did it

350
00:15:05,058 --> 00:15:10,458
you know oh we see it but was it here

351
00:15:07,850 --> 00:15:13,249
here here here here so it's a really

352
00:15:10,458 --> 00:15:15,498
powerful technique right and in fact

353
00:15:13,249 --> 00:15:18,619
there's probably more supernovae in

354
00:15:15,499 --> 00:15:20,839
these galaxies it's just we've kind of

355
00:15:18,619 --> 00:15:22,369
picked off the low-hanging fruit and

356
00:15:20,839 --> 00:15:24,860
there may be some faint ones that are

357
00:15:22,369 --> 00:15:27,350
very very hard to see and people can you

358
00:15:24,860 --> 00:15:29,419
know add up the points and maybe find a

359
00:15:27,350 --> 00:15:31,159
little little bump there but we've

360
00:15:29,419 --> 00:15:32,589
certainly picked the brightest ones

361
00:15:31,159 --> 00:15:33,879
that'll give us a lot

362
00:15:32,590 --> 00:15:35,889
more information about this tournament

363
00:15:33,879 --> 00:15:39,639
all right so let's get to the to what

364
00:15:35,889 --> 00:15:40,899
you found so the in 2011 you found two

365
00:15:39,639 --> 00:15:42,909
you've already pointed these out two

366
00:15:40,899 --> 00:15:45,340
massive supernovas these were red

367
00:15:42,909 --> 00:15:46,899
supergiant's that exploded while they

368
00:15:45,340 --> 00:15:49,300
were in Kepler's field of view and the

369
00:15:46,899 --> 00:15:52,299
first one was Kate you you have these

370
00:15:49,299 --> 00:15:56,199
really really cozy names real cuddly

371

00:15:52,299 --> 00:15:59,409
ones ksn 2011 a and the other one was

372
00:15:56,200 --> 00:16:01,180
ksn 2011 d tell us a little bit about

373
00:15:59,409 --> 00:16:02,769
the stars themselves and while we're at

374
00:16:01,179 --> 00:16:05,289
it let's go ahead and put up Scott if

375
00:16:02,769 --> 00:16:08,169
you don't mind the light curve of the

376
00:16:05,289 --> 00:16:09,459
supernova itself so we can see what they

377
00:16:08,169 --> 00:16:12,819
looked at and then we're going to talk

378
00:16:09,460 --> 00:16:14,530
about shot breakouts so Peter key Tesla

379
00:16:12,820 --> 00:16:18,430
did about the stars themselves and what

380
00:16:14,529 --> 00:16:21,250
there's these are enormous stars they're

381
00:16:18,429 --> 00:16:25,389
called red supergiant's for a reason the

382
00:16:21,250 --> 00:16:28,690
the radii are 500 sometimes a thousand

383
00:16:25,389 --> 00:16:31,569
times the radius as the Sun so the

384
00:16:28,690 --> 00:16:33,940
Earth's orbit would easily fit in in

385
00:16:31,570 --> 00:16:36,190

these stars and some red supergiant's

386

00:16:33,940 --> 00:16:39,130

even Mars's orbit would easily fit yeah

387

00:16:36,190 --> 00:16:41,230

inside the star so just completely

388

00:16:39,129 --> 00:16:45,100

different scale than what we're used to

389

00:16:41,230 --> 00:16:47,920

and we think of normal stars like like

390

00:16:45,100 --> 00:16:51,550

the Sun and maybe eventually the Sun

391

00:16:47,919 --> 00:16:52,959

will puff up to a red supergiant these

392

00:16:51,549 --> 00:16:56,439

are a little more massive than the Sun

393

00:16:52,960 --> 00:17:01,150

these are are maybe 10 to 15 solar mass

394

00:16:56,440 --> 00:17:02,440

stars evolved running out of hydrogen in

395

00:17:01,149 --> 00:17:05,019

their Center and now they're puffed up

396

00:17:02,440 --> 00:17:08,320

into these into these red supergiant's

397

00:17:05,019 --> 00:17:08,920

and so and but wait a minute okay now

398

00:17:08,319 --> 00:17:10,240

I'm confused

399

00:17:08,920 --> 00:17:12,970

I thought our Sun is gonna be a red

400
00:17:10,240 --> 00:17:15,730
giant and just shed its outer layers and

401
00:17:12,970 --> 00:17:18,250
write it because it's gonna be pretty

402
00:17:15,730 --> 00:17:20,230
big so that's what happens with the more

403
00:17:18,250 --> 00:17:22,119
massive stars as they can become red

404
00:17:20,230 --> 00:17:23,980
supergiant's okay well it's it so you

405
00:17:22,119 --> 00:17:26,679
did that you saw a couple of these and

406
00:17:23,980 --> 00:17:28,870
Scott Scott it up now this well you

407
00:17:26,680 --> 00:17:32,320
explain what are we looking at here so

408
00:17:28,869 --> 00:17:34,239
you know Kepler is relentless every 30

409
00:17:32,319 --> 00:17:37,629
minutes it's it's taking an image and

410
00:17:34,240 --> 00:17:42,880
and we get to make an observation on

411
00:17:37,630 --> 00:17:46,330
that and so as we look on the left side

412
00:17:42,880 --> 00:17:48,730
here we see the three

413
00:17:46,329 --> 00:17:51,519
explosion so we're looking at the at the

414
00:17:48,730 --> 00:17:54,579
galaxy constantly before the explosion

415
00:17:51,519 --> 00:17:58,440
and then in inside that white box

416
00:17:54,579 --> 00:17:58,439
there's a little flash kind of like a

417
00:17:58,798 --> 00:18:04,569
camera flash before it takes a picture

418
00:18:01,509 --> 00:18:08,259
and then that starts to fade and then we

419
00:18:04,569 --> 00:18:13,990
see the rise of supernova itself so this

420
00:18:08,259 --> 00:18:15,908
is the the slower rise is this expanding

421
00:18:13,990 --> 00:18:19,538
envelope of the star itself getting

422
00:18:15,909 --> 00:18:21,940
bigger over time and it takes about in

423
00:18:19,538 --> 00:18:24,990
this case about 13 days for the star to

424
00:18:21,940 --> 00:18:28,450
finally reaches its maximum brightness

425
00:18:24,990 --> 00:18:31,778
and that you know we've seen that before

426
00:18:28,450 --> 00:18:33,700
not in this kind of detail but what we

427
00:18:31,778 --> 00:18:36,278
haven't seen before is that little box

428

00:18:33,700 --> 00:18:38,798
in there where we have what's called a

429
00:18:36,278 --> 00:18:41,470
shock breakouts this is the initial

430
00:18:38,798 --> 00:18:46,450
explosion reaching the surface of this

431
00:18:41,470 --> 00:18:49,149
giant supergiant star and and originally

432
00:18:46,450 --> 00:18:51,460
there was a collapse of the core into a

433
00:18:49,148 --> 00:18:53,739
neutron star probably and that produced

434
00:18:51,460 --> 00:18:56,500
the shockwave which I actually took a

435
00:18:53,740 --> 00:18:58,808
day to reach the surface of the star and

436
00:18:56,500 --> 00:19:02,788
then we see the flash and then the

437
00:18:58,808 --> 00:19:04,839
expanding star yeah I can't see the

438
00:19:02,788 --> 00:19:05,980
x-axis on the because of everybody's

439
00:19:04,839 --> 00:19:07,959
thumbnails and the hang up but I'm

440
00:19:05,980 --> 00:19:10,089
looking at the image now and it shows so

441
00:19:07,960 --> 00:19:11,409
that but that bottom scale is in days in

442
00:19:10,089 --> 00:19:12,548

case I'm just not sure what people are

443

00:19:11,409 --> 00:19:15,130

being able to see when they in the

444

00:19:12,548 --> 00:19:17,619

hangout so it did that little that

445

00:19:15,130 --> 00:19:19,929

little bump there took several hours it

446

00:19:17,619 --> 00:19:23,138

looks like and you said it might have

447

00:19:19,929 --> 00:19:25,538

been due to a core collapse of a into a

448

00:19:23,138 --> 00:19:28,569

neutron star you said so that that's the

449

00:19:25,538 --> 00:19:31,990

the theory of of these kinds of

450

00:19:28,569 --> 00:19:34,269

supernovae massive stars they evolve

451

00:19:31,990 --> 00:19:36,700

they create all all heavier and heavier

452

00:19:34,269 --> 00:19:39,278

elements in their core eventually they

453

00:19:36,700 --> 00:19:41,649

create iron in their core and they can't

454

00:19:39,278 --> 00:19:46,179

get energy out anymore through fusion

455

00:19:41,648 --> 00:19:47,798

and the core will collapse down starting

456

00:19:46,179 --> 00:19:50,649

out maybe the size of the earth

457
00:19:47,798 --> 00:19:53,470
collapsing down to just 10 kilometers in

458
00:19:50,648 --> 00:19:55,269
size as a neutron star and then the rest

459
00:19:53,470 --> 00:19:57,429
of the star kind of bounces off of that

460
00:19:55,269 --> 00:19:59,599
there's a lot of physics we don't

461
00:19:57,429 --> 00:20:02,430
understand at this phase there's

462
00:19:59,599 --> 00:20:04,919
models don't seem to show the ability to

463
00:20:02,430 --> 00:20:08,700
actually explode the star unless there's

464
00:20:04,920 --> 00:20:10,680
extra physics involved including you

465
00:20:08,700 --> 00:20:13,950
know really bizarre exotic stuff like

466
00:20:10,680 --> 00:20:16,769
neutrinos being used to energize the

467
00:20:13,950 --> 00:20:19,319
inner part of the star but eventually a

468
00:20:16,769 --> 00:20:23,059
shock wave gets launched that moves

469
00:20:19,319 --> 00:20:25,529
through this this envelope that's

470
00:20:23,059 --> 00:20:28,079
hundreds of times the radius of the Sun

471
00:20:25,529 --> 00:20:32,210
and we don't even know that's coming

472
00:20:28,079 --> 00:20:35,250
until that flash arrives

473
00:20:32,210 --> 00:20:36,720
well we so we've got the light curve and

474
00:20:35,250 --> 00:20:37,890
we also got a little animation that kind

475
00:20:36,720 --> 00:20:39,089
of shows a little bit about what you're

476
00:20:37,890 --> 00:20:42,360
talking about and while Scott cues that

477
00:20:39,089 --> 00:20:45,720
up I'll just wait before we go there so

478
00:20:42,359 --> 00:20:48,899
so if I understand looking at this graph

479
00:20:45,720 --> 00:20:51,690
there's really no precursor to this it's

480
00:20:48,900 --> 00:20:53,759
just like boom and then it goes right am

481
00:20:51,690 --> 00:21:00,750
i right I mean you could say the shock

482
00:20:53,759 --> 00:21:04,440
breakout is telling you every flash and

483
00:21:00,750 --> 00:21:06,089
the rest of the star expands out and no

484
00:21:04,440 --> 00:21:09,120
you're right it's a lot of nothing

485

00:21:06,089 --> 00:21:10,759
before the excitement that's pretty

486
00:21:09,119 --> 00:21:12,869
early

487
00:21:10,759 --> 00:21:15,299
the excitement certainly thinks that

488
00:21:12,869 --> 00:21:17,029
one's good but you know it's every it's

489
00:21:15,299 --> 00:21:19,759
all good things you have to wait

490
00:21:17,029 --> 00:21:23,339
unfortunately Scott we're not seeing

491
00:21:19,759 --> 00:21:24,000
your screen yeah I can see it you can oh

492
00:21:23,339 --> 00:21:26,459
I can't

493
00:21:24,000 --> 00:21:36,089
wow we're okay well you tuned me not

494
00:21:26,460 --> 00:21:38,910
that much Carol if Kepler were in

495
00:21:36,089 --> 00:21:40,980
neutrino telescope so the neutrinos

496
00:21:38,910 --> 00:21:43,019
actually come out of the star very very

497
00:21:40,980 --> 00:21:45,000
easily there's not they don't interact

498
00:21:43,019 --> 00:21:47,789
with that with the gas and the envelope

499
00:21:45,000 --> 00:21:50,039

if we were to see this in neutrinos we

500

00:21:47,789 --> 00:21:52,980

would have seen a flash of neutrinos a

501

00:21:50,039 --> 00:21:55,740

day before we see the flash of the light

502

00:21:52,980 --> 00:21:59,759

so in in terms of precursor we're just

503

00:21:55,740 --> 00:22:02,009

on the right the right particles in

504

00:21:59,759 --> 00:22:05,339

photons instead of in nutrients yeah

505

00:22:02,009 --> 00:22:07,230

very difficult to see we pointed out

506

00:22:05,339 --> 00:22:09,059

there weakly interacting with us and so

507

00:22:07,230 --> 00:22:10,470

they go right straight through most

508

00:22:09,059 --> 00:22:11,940

things and they don't set off our

509

00:22:10,470 --> 00:22:13,889

detectors very well so

510

00:22:11,940 --> 00:22:15,629

that's hard they're hard to see but this

511

00:22:13,888 --> 00:22:17,158

is an explosion then even though it

512

00:22:15,628 --> 00:22:19,609

looks like an expansion of the outer

513

00:22:17,159 --> 00:22:23,278

atmosphere this is an explosion a

514
00:22:19,609 --> 00:22:25,109
supernova yes yes this is the the early

515
00:22:23,278 --> 00:22:28,138
moments when we first see it reach the

516
00:22:25,109 --> 00:22:31,079
surface of the star and it's two phases

517
00:22:28,138 --> 00:22:33,508
once the there's a shock inside which is

518
00:22:31,079 --> 00:22:35,759
a supernova as well and then we see it

519
00:22:33,509 --> 00:22:38,548
reaching the surface here and then the

520
00:22:35,759 --> 00:22:42,929
flash of the shock breakout and and the

521
00:22:38,548 --> 00:22:45,450
expanding envelope which which is the

522
00:22:42,929 --> 00:22:48,899
supernova itself okay

523
00:22:45,450 --> 00:22:51,210
well the this is the first time that

524
00:22:48,898 --> 00:22:55,378
this that this bow shock or this would

525
00:22:51,210 --> 00:22:57,808
have the shock wave has been seen or has

526
00:22:55,378 --> 00:22:59,668
been actually observed but this isn't a

527
00:22:57,808 --> 00:23:01,288
surprise right you guys knew this

528
00:22:59,669 --> 00:23:04,440
something like this would already happen

529
00:23:01,288 --> 00:23:06,210
correct or ISM just because it hadn't

530
00:23:04,440 --> 00:23:08,009
been observed as a mean you didn't know

531
00:23:06,210 --> 00:23:09,569
this something like this was there so

532
00:23:08,009 --> 00:23:12,240
this is the first time we've seen it at

533
00:23:09,569 --> 00:23:16,980
optical wavelengths it's actually been

534
00:23:12,240 --> 00:23:19,798
seen in in the ultraviolet in in in a

535
00:23:16,980 --> 00:23:22,319
few supernovae oh yeah

536
00:23:19,798 --> 00:23:24,119
that's not supergiant's not red

537
00:23:22,319 --> 00:23:26,788
supergiant's but in core collapse

538
00:23:24,119 --> 00:23:29,308
supernova there have been ultra violent

539
00:23:26,788 --> 00:23:30,990
officers okay great all right and most

540
00:23:29,308 --> 00:23:32,308
of those were lucky for in fact the

541
00:23:30,990 --> 00:23:33,990
first one was they were looking at

542

00:23:32,308 --> 00:23:35,398
another supernova and the supernova just

543
00:23:33,990 --> 00:23:38,159
happened to go off at the exact same

544
00:23:35,398 --> 00:23:40,199
moment so there was some evidence here

545
00:23:38,159 --> 00:23:42,659
and we wanted to kind of systematically

546
00:23:40,200 --> 00:23:44,069
you know on purpose search for it and

547
00:23:42,659 --> 00:23:45,179
look for it and I think when the

548
00:23:44,069 --> 00:23:47,609
interesting thing that's already come

549
00:23:45,179 --> 00:23:49,769
out as we saw the two soup exploding

550
00:23:47,609 --> 00:23:53,008
stars but we only saw the shockwave in

551
00:23:49,769 --> 00:23:54,628
one so already right there and looking

552
00:23:53,009 --> 00:23:56,308
at in a consistent way we know it's real

553
00:23:54,628 --> 00:23:58,439
but we only saw it and one is now was

554
00:23:56,308 --> 00:23:59,700
that because you didn't see it from the

555
00:23:58,440 --> 00:24:01,528
beginning or did you see it all

556
00:23:59,700 --> 00:24:03,659

completely through from the beginning uh

557

00:24:01,528 --> 00:24:06,148

why you said was a whole lot of nothing

558

00:24:03,659 --> 00:24:07,889

and then it got exciting real fast it or

559

00:24:06,148 --> 00:24:08,908

did you catch it at a different part of

560

00:24:07,888 --> 00:24:11,490

the light curve or did you see the

561

00:24:08,909 --> 00:24:14,789

entire thing and the one people for both

562

00:24:11,490 --> 00:24:17,429

we saw it the whole time we solo we we

563

00:24:14,788 --> 00:24:19,798

think with one there might be some some

564

00:24:17,429 --> 00:24:21,538

dusts or some other environmental

565

00:24:19,798 --> 00:24:24,359

circumstances that is preventing us from

566

00:24:21,538 --> 00:24:25,829

actually seeing that shockwave actually

567

00:24:24,359 --> 00:24:27,240

kind of reach it reach

568

00:24:25,829 --> 00:24:30,119

full brightness that's kind of being

569

00:24:27,240 --> 00:24:32,370

masked a little bit that that's our idea

570

00:24:30,119 --> 00:24:34,500

anyway but we saw the very early stages

571
00:24:32,369 --> 00:24:37,048
we saw really explode we just didn't see

572
00:24:34,500 --> 00:24:38,398
that quick shockwave so already it's

573
00:24:37,048 --> 00:24:39,990
telling us that there there is some

574
00:24:38,398 --> 00:24:43,439
interesting physics that goes on early

575
00:24:39,990 --> 00:24:45,630
times even more so than we kind of

576
00:24:43,440 --> 00:24:48,360
thought okay well these are being

577
00:24:45,630 --> 00:24:49,799
classified as type 2 supernova and you

578
00:24:48,359 --> 00:24:51,778
already mentioned that you that using

579
00:24:49,798 --> 00:24:54,240
Kepler data you found some type 1 A's

580
00:24:51,778 --> 00:24:56,640
tell us a little bit about what type 2

581
00:24:54,240 --> 00:24:58,349
are and how are they different from some

582
00:24:56,640 --> 00:25:00,000
of the other types of super also heard

583
00:24:58,349 --> 00:25:04,379
you say core-collapse is that is that

584
00:25:00,000 --> 00:25:05,638
synonymous so I tell my students all the

585
00:25:04,380 --> 00:25:09,360
time this is a kind of a complicated

586
00:25:05,638 --> 00:25:11,969
thing where astronomers have classified

587
00:25:09,359 --> 00:25:14,699
things based on their observations on on

588
00:25:11,970 --> 00:25:18,120
the spectra of of supernovae and it

589
00:25:14,700 --> 00:25:21,000
doesn't necessarily correlate match up

590
00:25:18,119 --> 00:25:24,148
one-to-one with what the models are for

591
00:25:21,000 --> 00:25:26,669
what we think is going on so a type 2

592
00:25:24,148 --> 00:25:30,209
supernova is just a supernova that shows

593
00:25:26,669 --> 00:25:31,830
hydrogen in its spectrum and a type 1

594
00:25:30,210 --> 00:25:34,500
supernova is one that doesn't show

595
00:25:31,829 --> 00:25:39,839
hydrogen in the spectra this goes way

596
00:25:34,500 --> 00:25:42,148
back to Ricky and bada and 100-inch

597
00:25:39,839 --> 00:25:44,638
telescope and their their first specter

598
00:25:42,148 --> 00:25:48,418
of of these things they realize there

599

00:25:44,638 --> 00:25:52,079
were two basic observational classes and

600
00:25:48,419 --> 00:25:55,288
and it turns out that type 1 supernova

601
00:25:52,079 --> 00:25:57,750
type 1 B and type 1 C supernovae are

602
00:25:55,288 --> 00:26:01,798
more related to type 2 and they are -

603
00:25:57,750 --> 00:26:03,450
the type 1 earth I sat down with Massimo

604
00:26:01,798 --> 00:26:04,619
C of LA one time in his office and he

605
00:26:03,450 --> 00:26:06,090
was trying to explain to me the

606
00:26:04,619 --> 00:26:09,148
different classifications of stars

607
00:26:06,089 --> 00:26:18,209
population to population 3 and all a

608
00:26:09,148 --> 00:26:20,308
makes this sounds like yeah this this

609
00:26:18,210 --> 00:26:24,899
just bolsters this statement that I say

610
00:26:20,308 --> 00:26:30,990
all the time astronomers just say stuff

611
00:26:24,898 --> 00:26:33,099
when they see it get in the way of a

612
00:26:30,990 --> 00:26:39,940
good transportation system

613
00:26:33,099 --> 00:26:42,638

know what that looks like what does that

614

00:26:39,940 --> 00:26:47,139

really mean astrophysically well nothing

615

00:26:42,638 --> 00:26:50,500

like dark matter but it comes out of

616

00:26:47,138 --> 00:26:52,569

your mouth and then it's sort of

617

00:26:50,500 --> 00:26:54,190

scientific Tourette's where you just

618

00:26:52,569 --> 00:26:58,028

blurt out little things they've been

619

00:26:54,190 --> 00:27:00,308

they somehow absolutely it's yeah you I

620

00:26:58,028 --> 00:27:02,259

know when I was excited doing my

621

00:27:00,308 --> 00:27:04,629

research and everybody else you just you

622

00:27:02,259 --> 00:27:06,700

turn into this child that gets so

623

00:27:04,630 --> 00:27:08,769

excited about anything come they're just

624

00:27:06,700 --> 00:27:11,110

words of nonsense come out and sometimes

625

00:27:08,769 --> 00:27:13,480

you get way too attached to one little

626

00:27:11,109 --> 00:27:16,778

thing even if it messes with everybody

627

00:27:13,480 --> 00:27:18,278

else's way of looking at the universe so

628
00:27:16,778 --> 00:27:28,569
I didn't come on this show to be

629
00:27:18,278 --> 00:27:30,579
ridiculed okay you didn't get that memo

630
00:27:28,569 --> 00:27:33,210
Peter that's it it over one memo you're

631
00:27:30,579 --> 00:27:33,210
here to get ridiculed

632
00:27:37,619 --> 00:27:45,339
you'll never be back you're right

633
00:27:42,519 --> 00:27:47,649
this is a historical thing we start out

634
00:27:45,339 --> 00:27:49,720
with no knowledge at all you start doing

635
00:27:47,648 --> 00:27:52,359
the observation than the classifications

636
00:27:49,720 --> 00:27:55,089
and only later do we find out that the

637
00:27:52,359 --> 00:27:56,168
the physics is is you know different

638
00:27:55,089 --> 00:27:58,808
than what we were doing with the

639
00:27:56,169 --> 00:28:01,269
classifications so in a classification

640
00:27:58,808 --> 00:28:04,599
in a in a physic sense we have basically

641
00:28:01,269 --> 00:28:07,538
two kinds of explosions we have massive

642
00:28:04,599 --> 00:28:09,969
stars that run out of energy in their

643
00:28:07,538 --> 00:28:11,919
center the core collapses down to a

644
00:28:09,970 --> 00:28:14,288
neutron stars maybe even a black hole

645
00:28:11,919 --> 00:28:16,799
sometimes and that we call a core

646
00:28:14,288 --> 00:28:19,359
collapse supernova and there are several

647
00:28:16,798 --> 00:28:22,048
spectroscopic types that correspond to

648
00:28:19,359 --> 00:28:26,138
that and the other side is a white dwarf

649
00:28:22,048 --> 00:28:28,808
that has a thermonuclear runaway runaway

650
00:28:26,138 --> 00:28:32,709
fusion in its center it's consumed in

651
00:28:28,808 --> 00:28:35,230
this in this fusion it it makes a type

652
00:28:32,710 --> 00:28:36,519
1a supernova and those are thus the

653
00:28:35,230 --> 00:28:38,710
basic two types

654
00:28:36,519 --> 00:28:40,960
okay well earlier I was asking you guys

655
00:28:38,710 --> 00:28:42,340
about the difference between the you

656

00:28:40,960 --> 00:28:44,288
know we tell my red giants and what our

657
00:28:42,339 --> 00:28:44,889
Sun is going to do and red supergiant

658
00:28:44,288 --> 00:28:47,829
and how the

659
00:28:44,890 --> 00:28:48,850
is different I've been taught and I'm

660
00:28:47,829 --> 00:28:50,589
thinking a lot of us have been taught

661
00:28:48,849 --> 00:28:53,649
that our Sun when it dies is gonna leave

662
00:28:50,589 --> 00:28:56,289
behind a white dwarf at its core and

663
00:28:53,650 --> 00:28:58,769
what about these type 2 supernovas what

664
00:28:56,289 --> 00:29:01,119
kind of remnant do they leave behind

665
00:28:58,769 --> 00:29:03,579
Brad you want to take that one yes and

666
00:29:01,119 --> 00:29:05,829
say so muslim' leave a neutron star and

667
00:29:03,579 --> 00:29:07,720
it's the the whole process is quite

668
00:29:05,829 --> 00:29:09,789
interesting right and we've known for a

669
00:29:07,720 --> 00:29:11,410
long time and believe you know we were

670
00:29:09,789 --> 00:29:13,210

talking about physics getting in the way

671

00:29:11,410 --> 00:29:14,560

well we've always had the physical

672

00:29:13,210 --> 00:29:16,420

understanding we just haven't had fully

673

00:29:14,559 --> 00:29:18,129

the observational understanding and I

674

00:29:16,420 --> 00:29:19,810

think a good way I always like to

675

00:29:18,130 --> 00:29:22,030

explain this is if you take dirt and

676

00:29:19,809 --> 00:29:24,309

compress it in your hand at some point

677

00:29:22,029 --> 00:29:26,589

you can't compress it enough and then

678

00:29:24,309 --> 00:29:28,679

your hands kind of bounce off and that's

679

00:29:26,589 --> 00:29:31,929

the process what happens it stars

680

00:29:28,680 --> 00:29:33,700

collapsed it and compress that material

681

00:29:31,930 --> 00:29:35,410

and then your hands have bounced off in

682

00:29:33,700 --> 00:29:38,049

that initial bouncing off is this shock

683

00:29:35,410 --> 00:29:40,330

wave so the majority of stars we think

684

00:29:38,049 --> 00:29:41,799

about are these core clip so Betelgeuse

685
00:29:40,329 --> 00:29:44,349
is going to be a core collapse star for

686
00:29:41,799 --> 00:29:47,169
instance so you know Betelgeuse and

687
00:29:44,349 --> 00:29:48,969
Orion is due to blow up any day as I say

688
00:29:47,170 --> 00:29:52,360
and in astronomy terms as you know that

689
00:29:48,970 --> 00:29:56,049
means like 20,000 years any day now

690
00:29:52,359 --> 00:29:57,729
but it is those are the general stars

691
00:29:56,049 --> 00:30:01,359
that were thought of and so they leave

692
00:29:57,730 --> 00:30:03,789
behind a neutron star we think even more

693
00:30:01,359 --> 00:30:06,399
larger supergiant stars can leave behind

694
00:30:03,789 --> 00:30:08,079
black holes though that process have

695
00:30:06,400 --> 00:30:09,759
never been saved you've never actually

696
00:30:08,079 --> 00:30:12,159
seen the neutron star and there's not

697
00:30:09,759 --> 00:30:13,329
necessarily a really hard boundary

698
00:30:12,160 --> 00:30:14,769
between when you get a neutron star

699
00:30:13,329 --> 00:30:16,329
versus a black hole core I mean it's

700
00:30:14,769 --> 00:30:18,309
kind of a range of their conditions

701
00:30:16,329 --> 00:30:19,869
exactly we think there's a range and we

702
00:30:18,309 --> 00:30:22,210
would like to see this direct process

703
00:30:19,869 --> 00:30:25,179
happening and so we infer that there's a

704
00:30:22,210 --> 00:30:27,850
neutron star but we obviously didn't see

705
00:30:25,180 --> 00:30:30,310
the neutron stars so this shock breakout

706
00:30:27,849 --> 00:30:31,779
that we were talking about today I love

707
00:30:30,309 --> 00:30:33,399
what you just said it was you know this

708
00:30:31,779 --> 00:30:34,930
idea that you're pushing and pushing on

709
00:30:33,400 --> 00:30:37,300
the core and boom you're bounced back

710
00:30:34,930 --> 00:30:39,430
that is what we're seeing right it's

711
00:30:37,299 --> 00:30:41,859
that sort of push back from the collapse

712
00:30:39,430 --> 00:30:44,019
of this core of this core and a neutron

713

00:30:41,859 --> 00:30:47,500
star is extremely dense give us an idea

714
00:30:44,019 --> 00:30:49,509
just how dense that is so I think if you

715
00:30:47,500 --> 00:30:54,339
were to take a spoonful of the Sun you

716
00:30:49,509 --> 00:30:57,069
get about five grams of material that

717
00:30:54,339 --> 00:30:58,419
tasty Sun now neutron stars and it's

718
00:30:57,069 --> 00:30:59,859
tasty

719
00:30:58,420 --> 00:31:01,900
but I think if you take a better

720
00:30:59,859 --> 00:31:04,469
neutrons a spoonful of a neutron star

721
00:31:01,900 --> 00:31:07,630
you get about a hundred thousand grams

722
00:31:04,470 --> 00:31:10,839
so neutron stars are much more dense now

723
00:31:07,630 --> 00:31:13,450
it's not as dense as the black coal but a

724
00:31:10,839 --> 00:31:16,990
you know the the neutron star that would

725
00:31:13,450 --> 00:31:18,640
have been created in this this explosion

726
00:31:16,990 --> 00:31:21,130
that we saw would have been smaller than

727
00:31:18,640 --> 00:31:23,500

the earth physical size so the radius

728

00:31:21,130 --> 00:31:25,630

would have been smaller than the earth

729

00:31:23,500 --> 00:31:28,240

but it would have been heavier than the

730

00:31:25,630 --> 00:31:30,040

Sun so these are really dense really

731

00:31:28,240 --> 00:31:32,230

heavy things okay well let me get to

732

00:31:30,039 --> 00:31:34,059

Astro girl one usa's question which is

733

00:31:32,230 --> 00:31:36,819

and welcome back by the way it's good to

734

00:31:34,059 --> 00:31:38,730

see you back so she's asking a very

735

00:31:36,819 --> 00:31:41,649

relevant question at this point do all

736

00:31:38,730 --> 00:31:43,509

supernovae have shockwaves or just type

737

00:31:41,650 --> 00:31:45,220

two that bounce back you're talking

738

00:31:43,509 --> 00:31:47,140

about is that only is that a signature

739

00:31:45,220 --> 00:31:50,710

of type two or will we see that

740

00:31:47,140 --> 00:31:54,640

somewhere else another life supernova so

741

00:31:50,710 --> 00:31:56,860

yeah I think it was it's true that all

742
00:31:54,640 --> 00:31:59,259
core-collapse supernovae so these are

743
00:31:56,859 --> 00:32:02,759
these are things where that neutron star

744
00:31:59,259 --> 00:32:06,369
is is formed and it has an outer layer

745
00:32:02,759 --> 00:32:08,680
envelope to it that they're the shock

746
00:32:06,369 --> 00:32:11,979
the breakout will occur in all of these

747
00:32:08,680 --> 00:32:14,049
different brightnesses so it turns out

748
00:32:11,980 --> 00:32:16,960
that these red supergiant's which are

749
00:32:14,049 --> 00:32:18,970
are so large give you brighter shock

750
00:32:16,960 --> 00:32:21,789
breakouts than something more compact

751
00:32:18,970 --> 00:32:24,610
where the hydrogen envelope has been

752
00:32:21,789 --> 00:32:26,769
lost or something like that so you'll

753
00:32:24,609 --> 00:32:28,209
still get a shock breakout but it's not

754
00:32:26,769 --> 00:32:32,950
going to be as bright as you see in

755
00:32:28,210 --> 00:32:34,660
these very large red supergiant stars no

756
00:32:32,950 --> 00:32:35,740
so these are fascinating okay well I'm

757
00:32:34,660 --> 00:32:38,200
gonna go back I want to go back to a

758
00:32:35,740 --> 00:32:40,000
Twitter comment that Joel Edward 86

759
00:32:38,200 --> 00:32:42,700
asked and this is sort of goes back to

760
00:32:40,000 --> 00:32:43,990
what you were just commenting on Brad so

761
00:32:42,700 --> 00:32:45,370
I'd like you to follow up with this you

762
00:32:43,990 --> 00:32:48,160
mentioned Betelgeuse so I'm gonna go

763
00:32:45,369 --> 00:32:50,529
ahead let's do it is Betelgeuse near two

764
00:32:48,160 --> 00:32:52,570
supernova and you said any day now and

765
00:32:50,529 --> 00:32:54,430
if so what would that look like from the

766
00:32:52,569 --> 00:32:57,099
earth tell us about what that might look

767
00:32:54,430 --> 00:33:01,060
like it'd be awesome firstly I made a

768
00:32:57,099 --> 00:33:05,049
you know you're just blowing me away

769
00:33:01,059 --> 00:33:07,859
okay it's a I'm really waiting for

770

00:33:05,049 --> 00:33:11,960
Betelgeuse to blow up I call it employer

771
00:33:07,859 --> 00:33:15,019
you know it's Betelgeuse

772
00:33:11,960 --> 00:33:17,720
we'll be very bright you know it's not

773
00:33:15,019 --> 00:33:19,099
gonna be like a new Sun I mean I think

774
00:33:17,720 --> 00:33:20,808
some people think that it will just be

775
00:33:19,099 --> 00:33:23,629
this you know there's very bright thing

776
00:33:20,808 --> 00:33:25,789
firstly we'll see the neutrinos first so

777
00:33:23,630 --> 00:33:27,410
the those high-energy particles that

778
00:33:25,789 --> 00:33:29,599
we're talking about earlier leaving the

779
00:33:27,410 --> 00:33:30,860
the inside of the star we should be able

780
00:33:29,599 --> 00:33:32,990
to see them with our ground-based

781
00:33:30,859 --> 00:33:35,808
detectors and kind of know about it a

782
00:33:32,990 --> 00:33:37,849
few minutes ahead of time and then we'll

783
00:33:35,808 --> 00:33:40,700
see the light I think their general

784
00:33:37,849 --> 00:33:43,250

consensus is when Betelgeuse blows up it

785

00:33:40,700 --> 00:33:44,808

will be bright for months visible to the

786

00:33:43,250 --> 00:33:47,420

naked eye

787

00:33:44,808 --> 00:33:48,859

we should probably you know at peak you

788

00:33:47,420 --> 00:33:51,440

know probably brighter than the full

789

00:33:48,859 --> 00:33:54,259

moon that's what we may be able to see

790

00:33:51,440 --> 00:33:56,120

it then we'd be able to potentially I

791

00:33:54,259 --> 00:33:58,970

mean there is you know debate about

792

00:33:56,119 --> 00:34:00,949

exactly how bright it is it's we there's

793

00:33:58,970 --> 00:34:03,740

very few cases where we've seen a very

794

00:34:00,950 --> 00:34:08,720

studied evolve star and then see it blow

795

00:34:03,740 --> 00:34:11,210

up but it will be a good example 1987a

796

00:34:08,719 --> 00:34:12,829

the supernova we call 1987a which

797

00:34:11,210 --> 00:34:15,769

occurred in our neighbor galaxy the

798

00:34:12,829 --> 00:34:18,019

Large Magellanic Cloud now this is

799
00:34:15,769 --> 00:34:19,550
thousands of light years are tens of

800
00:34:18,019 --> 00:34:21,648
thousands of light years away but when

801
00:34:19,550 --> 00:34:23,179
it blew up it was so bright our

802
00:34:21,648 --> 00:34:25,819
professional telescopes couldn't

803
00:34:23,179 --> 00:34:27,800
actually even use it because it was so

804
00:34:25,820 --> 00:34:29,149
bright it saturated our measurement so

805
00:34:27,800 --> 00:34:32,750
you can imagine something that's in our

806
00:34:29,148 --> 00:34:35,148
backyard how bright scaling wise that

807
00:34:32,750 --> 00:34:36,469
would be so whenever it blows up it

808
00:34:35,148 --> 00:34:37,789
won't harm the earth you know we're not

809
00:34:36,469 --> 00:34:39,408
we're not in trouble we're not in danger

810
00:34:37,789 --> 00:34:43,759
we don't have to call Bruce Willis or

811
00:34:39,409 --> 00:34:46,820
anything like that but it will be a Cool

812
00:34:43,760 --> 00:34:48,980
J Willis at it but it'll be a great show

813
00:34:46,820 --> 00:34:51,050
nonetheless yeah we're gonna have them

814
00:34:48,980 --> 00:34:53,148
go drill the supernova just just think

815
00:34:51,050 --> 00:35:03,170
exactly Oh Smith playing in the

816
00:34:53,148 --> 00:35:05,389
background I'm with you well the the so

817
00:35:03,170 --> 00:35:06,800
they have what about the the density of

818
00:35:05,389 --> 00:35:09,079
these star oh I know what I want to get

819
00:35:06,800 --> 00:35:11,030
to so I'm gonna go back to the neutrino

820
00:35:09,079 --> 00:35:13,759
comment you made earlier we have

821
00:35:11,030 --> 00:35:15,080
detectors you the ground-based detectors

822
00:35:13,760 --> 00:35:16,670
are deep underground I think some of

823
00:35:15,079 --> 00:35:18,559
them are in Japan some of our might I

824
00:35:16,670 --> 00:35:20,900
forget where they all are one of them is

825
00:35:18,559 --> 00:35:23,269
called super k kamiokande or something

826
00:35:20,900 --> 00:35:25,550
like that those are those all those are

827

00:35:23,269 --> 00:35:27,519
always on right and they will

828
00:35:25,550 --> 00:35:29,810
TEKT an influx of neutrinos do you guys

829
00:35:27,519 --> 00:35:31,159
rely on that as any kind of early

830
00:35:29,809 --> 00:35:32,690
warning system at all do they let you

831
00:35:31,159 --> 00:35:35,690
guys know when they're when they see a

832
00:35:32,690 --> 00:35:37,450
sudden influx of neutrinos it's it's

833
00:35:35,690 --> 00:35:41,480
funny that you say that but there is a

834
00:35:37,449 --> 00:35:43,159
network of neutrino detectors I think

835
00:35:41,480 --> 00:35:48,260
it's true they're awesome or something

836
00:35:43,159 --> 00:35:52,579
yeah supernova alert yeah yeah and and I

837
00:35:48,260 --> 00:35:55,640
I am signed up for it so if several of

838
00:35:52,579 --> 00:35:59,119
these neutrino detectors show a spike in

839
00:35:55,639 --> 00:36:01,489
rates they they will send out an

840
00:35:59,119 --> 00:36:04,309
automatic alert saying hey something is

841
00:36:01,489 --> 00:36:06,799

going on and and then it'll be up to us

842

00:36:04,309 --> 00:36:09,500

optical astronomers to go out and and

843

00:36:06,800 --> 00:36:12,080

look for a galactic supernova because

844

00:36:09,500 --> 00:36:14,780

they won't have the sensitivity beyond

845

00:36:12,079 --> 00:36:17,630

save a large and small Magellanic Clouds

846

00:36:14,780 --> 00:36:20,420

so I'm not even sure Andromeda they'll

847

00:36:17,630 --> 00:36:23,720

be able to detect very much but in our

848

00:36:20,420 --> 00:36:26,480

galaxy it should be a fairly clear spike

849

00:36:23,719 --> 00:36:28,629

of neutrinos these days the the neutrino

850

00:36:26,480 --> 00:36:32,030

detectors have gotten a lot better since

851

00:36:28,630 --> 00:36:35,840

1987 when I think it was 19 or 18

852

00:36:32,030 --> 00:36:38,360

neutrinos were detected from 1987a and

853

00:36:35,840 --> 00:36:40,519

the Large Magellanic Cloud so they're

854

00:36:38,360 --> 00:36:42,820

expecting thousands of neutrinos to be

855

00:36:40,519 --> 00:36:45,440

detected from a galactic supernova and

856
00:36:42,820 --> 00:36:47,720
it should be a pretty clear signal and

857
00:36:45,440 --> 00:36:50,840
then we can go start looking for it in

858
00:36:47,719 --> 00:36:53,629
the optical are they directional enough

859
00:36:50,840 --> 00:36:55,490
to give you a sense of where to look I

860
00:36:53,630 --> 00:36:57,079
mean I know that these they only you

861
00:36:55,489 --> 00:36:59,719
only have a few neutrinos to work with

862
00:36:57,079 --> 00:37:01,880
each time but if several throughout the

863
00:36:59,719 --> 00:37:02,839
globe were able to detect them can you

864
00:37:01,880 --> 00:37:07,809
kind of get a sense of where they're

865
00:37:02,840 --> 00:37:07,809
coming from or so I I'm not sure that

866
00:37:08,079 --> 00:37:14,389
that any any couple of neutrinos will do

867
00:37:12,110 --> 00:37:17,660
it but the large number of neutrinos

868
00:37:14,389 --> 00:37:20,690
that say go to super-k you can get a

869
00:37:17,659 --> 00:37:23,449
directional signal from that the flash

870
00:37:20,690 --> 00:37:25,309
of strength off radiation points in the

871
00:37:23,449 --> 00:37:27,259
opposite direction general opposite

872
00:37:25,309 --> 00:37:29,570
direction of where the where the

873
00:37:27,260 --> 00:37:32,180
neutrino came from so we could probably

874
00:37:29,570 --> 00:37:35,539
narrow it down to maybe twenty or thirty

875
00:37:32,179 --> 00:37:37,309
degrees on the sky where the where the

876
00:37:35,539 --> 00:37:39,559
supernova is coming from and a core

877
00:37:37,309 --> 00:37:41,659
collapse supernovae generally comes from

878
00:37:39,559 --> 00:37:43,730
an extremely young population of stars

879
00:37:41,659 --> 00:37:46,879
so it will probably be constrained to

880
00:37:43,730 --> 00:37:48,940
the disk of our galaxy so we'll know

881
00:37:46,880 --> 00:37:52,789
pretty well from the neutrino flash

882
00:37:48,940 --> 00:37:54,200
where where doesn't don't look so wait a

883
00:37:52,789 --> 00:37:56,630
minute these two supernovas we're

884

00:37:54,199 --> 00:37:58,460
talking about today they are from

885
00:37:56,630 --> 00:37:59,869
galaxies pretty far away then we're

886
00:37:58,460 --> 00:38:03,170
talking billions of light-years away

887
00:37:59,869 --> 00:38:04,819
right so we would not necessarily where

888
00:38:03,170 --> 00:38:06,610
we probably wouldn't I don't think get

889
00:38:04,820 --> 00:38:09,940
any neutrinos from these would be

890
00:38:06,610 --> 00:38:12,320
absolutely not say they are very distant

891
00:38:09,940 --> 00:38:15,559
so like I was saying even even though

892
00:38:12,320 --> 00:38:17,960
our nearest galaxies Andromeda and

893
00:38:15,559 --> 00:38:20,869
beyond I don't think it's possible to

894
00:38:17,960 --> 00:38:22,579
get a together you to know that so

895
00:38:20,869 --> 00:38:24,949
neutrino detectors are very helpful for

896
00:38:22,579 --> 00:38:26,480
things happening within our galaxy I

897
00:38:24,949 --> 00:38:28,039
mean and I think that's kind of the

898
00:38:26,480 --> 00:38:29,690

impressive part when we go back to about

899

00:38:28,039 --> 00:38:32,179

these Kepler observations we're seeing a

900

00:38:29,690 --> 00:38:35,630

shock wave from a neutron star that was

901

00:38:32,179 --> 00:38:39,049

created in the collection of a star 1.2

902

00:38:35,630 --> 00:38:41,300

billion light-years away and that's how

903

00:38:39,050 --> 00:38:42,590

sensitive Kepler is you can't do this

904

00:38:41,300 --> 00:38:45,140

from the ground you can't do this with

905

00:38:42,590 --> 00:38:47,150

other instruments and that is where the

906

00:38:45,139 --> 00:38:49,879

the strengths of Kepler has really

907

00:38:47,150 --> 00:38:51,349

allowed us to do these discoveries and I

908

00:38:49,880 --> 00:38:52,700

was so easy doing these hangouts to just

909

00:38:51,349 --> 00:38:54,920

be flippant about numbers like that oh

910

00:38:52,699 --> 00:38:56,509

yeah 1.2 1.2 million what's a couple

911

00:38:54,920 --> 00:38:58,670

million light-years between friends I

912

00:38:56,510 --> 00:39:00,500

don't get the problem here so oK we've

913
00:38:58,670 --> 00:39:02,630
got some more good questions here I want

914
00:39:00,500 --> 00:39:05,809
to get to some of them here what

915
00:39:02,630 --> 00:39:07,700
Christopher boy it must be Pettersen

916
00:39:05,809 --> 00:39:09,019
with all those T's so I an S is so I'm

917
00:39:07,699 --> 00:39:11,029
just gonna say it that way Christopher

918
00:39:09,019 --> 00:39:14,900
Patterson what is the density of these

919
00:39:11,030 --> 00:39:17,240
giant stars compared to the Sun do these

920
00:39:14,900 --> 00:39:19,300
giants just get bloated once the star

921
00:39:17,239 --> 00:39:21,379
mass or the mass starts to go up now

922
00:39:19,300 --> 00:39:22,730
that I'm kind of wondering you know I

923
00:39:21,380 --> 00:39:25,340
was kind of clarifying that a little bit

924
00:39:22,730 --> 00:39:26,510
earlier in the hangout how do these what

925
00:39:25,340 --> 00:39:28,490
is it what are the density of these

926
00:39:26,510 --> 00:39:29,510
stars and we you give the size in the

927
00:39:28,489 --> 00:39:32,059
press release but we don't talk about

928
00:39:29,510 --> 00:39:33,380
the mass so much how do these how do

929
00:39:32,059 --> 00:39:36,320
they compare as far as the mass of the

930
00:39:33,380 --> 00:39:38,570
Sun and the density right so our

931
00:39:36,320 --> 00:39:40,910
observations actually are pretty good at

932
00:39:38,570 --> 00:39:43,160
constraining the size of the star when

933
00:39:40,909 --> 00:39:45,349
it exploded but not very good at

934
00:39:43,159 --> 00:39:48,409
constraining the mass so we rely on

935
00:39:45,349 --> 00:39:50,659
models for that and in general the core

936
00:39:48,409 --> 00:39:53,119
collapse supernovae will only happen for

937
00:39:50,659 --> 00:39:56,239
stars that are about 8 solar masses

938
00:39:53,119 --> 00:39:58,279
and and higher so start there it's got

939
00:39:56,239 --> 00:39:59,959
less than that right it's not less than

940
00:39:58,280 --> 00:40:02,750
that less than that you end up with

941

00:39:59,960 --> 00:40:05,869
white doors being formed stable white

942
00:40:02,750 --> 00:40:09,199
dwarves more than that you can get core

943
00:40:05,869 --> 00:40:11,960
collapse supernovae and and and so these

944
00:40:09,199 --> 00:40:14,029
stars are are typically because there

945
00:40:11,960 --> 00:40:15,710
are many more lower mass stars and high

946
00:40:14,030 --> 00:40:19,970
mass stars they're going to be typically

947
00:40:15,710 --> 00:40:22,490
10 to 15 solar masses in when they

948
00:40:19,969 --> 00:40:28,849
finally evolve to the point of exploding

949
00:40:22,489 --> 00:40:31,549
now yes it's not bad you know but still

950
00:40:28,849 --> 00:40:33,949
corresponds to a 300 times and a 500

951
00:40:31,550 --> 00:40:36,110
times a respective Li of the size of our

952
00:40:33,949 --> 00:40:39,439
own Sun so it's a pretty big star for

953
00:40:36,110 --> 00:40:41,990
sure it's a big star not that much more

954
00:40:39,440 --> 00:40:43,760
mass so in fact as Brad was saying you

955
00:40:41,989 --> 00:40:46,909

take a little bit of the Sun and you get

956

00:40:43,760 --> 00:40:49,580

like 3 3 grams because the kind of the

957

00:40:46,909 --> 00:40:51,799

average density of the Sun take it as a

958

00:40:49,579 --> 00:40:56,090

whole is on the order of the density of

959

00:40:51,800 --> 00:40:58,760

water but these stars are a few times 15

960

00:40:56,090 --> 00:41:00,680

times more massive than the Sun but you

961

00:40:58,760 --> 00:41:03,020

know a thousand times bigger so they're

962

00:41:00,679 --> 00:41:08,149

their average density is very very low

963

00:41:03,019 --> 00:41:10,429

it's you know it's air at the very edges

964

00:41:08,150 --> 00:41:13,160

a good question question for thank you

965

00:41:10,429 --> 00:41:14,509

so a stronger one USA I'm gonna ask this

966

00:41:13,159 --> 00:41:16,190

question even though I've read it

967

00:41:14,510 --> 00:41:18,170

several times I may ask you to clarify

968

00:41:16,190 --> 00:41:19,099

it because I'm not sure I understand

969

00:41:18,170 --> 00:41:21,019

what you mean I'm gonna say what I think

970
00:41:19,099 --> 00:41:21,679
you mean and if I'm wrong please comment

971
00:41:21,019 --> 00:41:23,509
on it

972
00:41:21,679 --> 00:41:25,159
she's asking do we have a way of

973
00:41:23,510 --> 00:41:27,500
including dark energy in our

974
00:41:25,159 --> 00:41:29,299
calculations of how far away a type 1a

975
00:41:27,500 --> 00:41:31,400
supernova is now type 1a are these

976
00:41:29,300 --> 00:41:33,050
standard candles where that they have we

977
00:41:31,400 --> 00:41:34,309
know their intrinsic brightness and by

978
00:41:33,050 --> 00:41:36,500
knowing their intrinsic brightness we

979
00:41:34,309 --> 00:41:38,329
can estimate their their distance based

980
00:41:36,500 --> 00:41:40,369
on that we can calculate their distance

981
00:41:38,329 --> 00:41:43,759
I think what she's asking is because the

982
00:41:40,369 --> 00:41:45,440
dark energy expanding of the universe

983
00:41:43,760 --> 00:41:47,660
during the time of the explosion perhaps

984
00:41:45,440 --> 00:41:49,880
do we have a way of compensating for the

985
00:41:47,659 --> 00:41:52,639
effects of dark energy I hope I asked

986
00:41:49,880 --> 00:41:53,720
that right astro girl 1 USA it doesn't

987
00:41:52,639 --> 00:41:56,929
make sense what I've asked you just now

988
00:41:53,719 --> 00:41:59,959
Peter and Brad well not not completely

989
00:41:56,929 --> 00:42:02,839
to me I you know I I think when we're

990
00:41:59,960 --> 00:42:04,460
talking about distant supernovae the

991
00:42:02,840 --> 00:42:06,559
light has to travel through the universe

992
00:42:04,460 --> 00:42:09,170
and then we need

993
00:42:06,559 --> 00:42:10,460
take into account dark energy to account

994
00:42:09,170 --> 00:42:13,400
for the exciting that's what she's

995
00:42:10,460 --> 00:42:16,579
asking so there would be an expansion of

996
00:42:13,400 --> 00:42:19,430
the universe with moves being annexed

997
00:42:16,579 --> 00:42:20,750
so I got that right okay so do we do

998

00:42:19,429 --> 00:42:22,219
that I mean I don't know that we know

999
00:42:20,750 --> 00:42:23,510
and I guess the Hubble constant comes

1000
00:42:22,219 --> 00:42:25,429
into play that's this number that gives

1001
00:42:23,510 --> 00:42:28,520
us the rate of expansion any given time

1002
00:42:25,429 --> 00:42:31,099
in the universe do we apply these when

1003
00:42:28,519 --> 00:42:34,550
you look at these 1.2 billion light year

1004
00:42:31,099 --> 00:42:38,119
galaxies so 1.2 billion laser sounds

1005
00:42:34,550 --> 00:42:40,220
like a very very far away galaxy really

1006
00:42:38,119 --> 00:42:44,480
girly when it comes to the cosmological

1007
00:42:40,219 --> 00:42:47,239
expansion and that the effects of dark

1008
00:42:44,480 --> 00:42:50,539
energy it's it's not that important so

1009
00:42:47,239 --> 00:42:53,209
yeah we're talking about is not an it's

1010
00:42:50,539 --> 00:42:55,969
not ideal right so dark energy was

1011
00:42:53,210 --> 00:43:00,050
discovered using supernovae at distances

1012
00:42:55,969 --> 00:43:02,269

of like five billion light years so a

1013

00:43:00,050 --> 00:43:05,539

billion light years is just a little too

1014

00:43:02,269 --> 00:43:08,449

close for for it to be an important a

1015

00:43:05,539 --> 00:43:09,949

part of the of the light that's a good

1016

00:43:08,449 --> 00:43:11,809

point by comparison the observable

1017

00:43:09,949 --> 00:43:14,960

universe is has a radius of forty

1018

00:43:11,809 --> 00:43:16,610

billion light years so so yeah I guess

1019

00:43:14,960 --> 00:43:18,980

you're right on that scale that's pretty

1020

00:43:16,610 --> 00:43:21,170

small dynamic universe on YouTube is

1021

00:43:18,980 --> 00:43:23,240

asking do they know why some stars about

1022

00:43:21,170 --> 00:43:26,000

the mass of the Sun puff the outer

1023

00:43:23,239 --> 00:43:28,099

layers like in the cat's eye nebula or

1024

00:43:26,000 --> 00:43:31,639

these the ring nebula which is another

1025

00:43:28,099 --> 00:43:35,239

famous one note from Scott better read

1026

00:43:31,639 --> 00:43:36,980

that one that's me yeah your head I was

1027
00:43:35,239 --> 00:43:38,929
just talking about since we just talked

1028
00:43:36,980 --> 00:43:41,030
about going right to white dwarf maybe

1029
00:43:38,929 --> 00:43:42,789
include the part where planetary nebula

1030
00:43:41,030 --> 00:43:45,140
is something it could happen with ours

1031
00:43:42,789 --> 00:43:49,070
okay so yeah so why don't we talk about

1032
00:43:45,139 --> 00:43:51,139
that why do some stars like our Sun just

1033
00:43:49,070 --> 00:43:53,510
shed its outer layer of gas and

1034
00:43:51,139 --> 00:43:56,679
essentially by comparison to a pretty

1035
00:43:53,510 --> 00:44:01,880
boring thing and other stars do this

1036
00:43:56,679 --> 00:44:03,769
Brad you got up early for this one train

1037
00:44:01,880 --> 00:44:06,460
your brain see this onion I don't know

1038
00:44:03,769 --> 00:44:06,460
what you're talking about

1039
00:44:12,130 --> 00:44:16,570
the Sun is dead to me

1040
00:44:17,179 --> 00:44:28,559
Tony can't see the Sun either oh it's

1041
00:44:20,789 --> 00:44:36,300
it's just this now I just Scott I they

1042
00:44:28,559 --> 00:44:38,309
rarely see the Sun as it is okay I think

1043
00:44:36,300 --> 00:44:40,530
that's a good question it is all part of

1044
00:44:38,309 --> 00:44:43,019
this this uding using the fuel that as

1045
00:44:40,530 --> 00:44:45,090
you use the the first layers of feel the

1046
00:44:43,019 --> 00:44:46,800
hydrogen feel those layers get

1047
00:44:45,090 --> 00:44:49,289
eventually puffed out and then you go

1048
00:44:46,800 --> 00:44:51,539
through the heavier elements to helium

1049
00:44:49,289 --> 00:44:52,529
and then you do some carbon and oxygen

1050
00:44:51,539 --> 00:44:54,809
and oxygen

1051
00:44:52,530 --> 00:44:56,220
all of those slowly get puffed out now

1052
00:44:54,809 --> 00:44:58,829
in a smaller star like our Sun

1053
00:44:56,219 --> 00:45:01,679
eventually those things have just puffed

1054
00:44:58,829 --> 00:45:04,949
out over time and you're left with that

1055

00:45:01,679 --> 00:45:08,159
iron core that white dwarf which brought

1056
00:45:04,949 --> 00:45:10,589
it burns a little bit bright but burns

1057
00:45:08,159 --> 00:45:13,799
inside the star creating these not very

1058
00:45:10,590 --> 00:45:15,870
nice planetary nebulae whereas with

1059
00:45:13,800 --> 00:45:19,590
these these heavier stars that blow off

1060
00:45:15,869 --> 00:45:22,349
if they were not to collapse in on

1061
00:45:19,590 --> 00:45:26,430
themselves you would get great nebulae

1062
00:45:22,349 --> 00:45:28,409
you would get huge balls of this gas of

1063
00:45:26,429 --> 00:45:29,879
the hydrogen expanding and the helium

1064
00:45:28,409 --> 00:45:33,750
and all these other gases you would get

1065
00:45:29,880 --> 00:45:36,059
massive nebulae that would be fantastic

1066
00:45:33,750 --> 00:45:38,610
but the process you know gravity

1067
00:45:36,059 --> 00:45:39,630
ultimately wins gravity is heartless it

1068
00:45:38,610 --> 00:45:42,329
always wins

1069
00:45:39,630 --> 00:45:45,930

and so these stars collapse and so

1070

00:45:42,329 --> 00:45:48,690

before it gets to that phase it blows up

1071

00:45:45,929 --> 00:45:50,519

so in theory you could get a large star

1072

00:45:48,690 --> 00:45:52,829

that creates a planetary nebulae but

1073

00:45:50,519 --> 00:45:54,719

it's just unlikely to create such a

1074

00:45:52,829 --> 00:45:56,309

large one without collapsing well what

1075

00:45:54,719 --> 00:45:58,199

you get instead is more like what the

1076

00:45:56,309 --> 00:46:00,630

Crab Nebula is right you get more of a

1077

00:45:58,199 --> 00:46:02,789

nebula that was created from our core

1078

00:46:00,630 --> 00:46:04,410

that's what will create a slightly

1079

00:46:02,789 --> 00:46:06,420

different I mean those those dad's gas

1080

00:46:04,409 --> 00:46:08,519

layers will expand and you know

1081

00:46:06,420 --> 00:46:10,470

eventually those form the new stars

1082

00:46:08,519 --> 00:46:12,659

right you know that's it is that process

1083

00:46:10,469 --> 00:46:14,369

this is this this whole process of going

1084
00:46:12,659 --> 00:46:16,529
on and I always like to stress the

1085
00:46:14,369 --> 00:46:18,650
universe is good at recycling right yeah

1086
00:46:16,530 --> 00:46:18,650
exactly

1087
00:46:18,659 --> 00:46:24,420
yes the trick yeah look at that if you

1088
00:46:22,260 --> 00:46:27,720
look at the Crab Nebula the velocities

1089
00:46:24,420 --> 00:46:28,970
of that are much much higher than in a

1090
00:46:27,719 --> 00:46:32,959
planetary nebula

1091
00:46:28,969 --> 00:46:34,848
the crabby above- of the result of an

1092
00:46:32,960 --> 00:46:38,059
explosion as a core collapse supernova

1093
00:46:34,849 --> 00:46:40,609
there they're like twenty thousand ten

1094
00:46:38,059 --> 00:46:43,880
thousand kilometers per second well when

1095
00:46:40,608 --> 00:46:46,309
you look at a planetary nebula coming

1096
00:46:43,880 --> 00:46:48,980
from a lower mass star the velocities

1097
00:46:46,309 --> 00:46:51,980
are much lower it's ten kilometers per

1098
00:46:48,980 --> 00:46:55,699
second this is a much gentle gentle er

1099
00:46:51,980 --> 00:46:57,469
poof as as Brad was saying of gas going

1100
00:46:55,699 --> 00:47:00,529
off of this this star that will

1101
00:46:57,469 --> 00:47:03,318
eventually become a white dwarf so they

1102
00:47:00,530 --> 00:47:04,760
kind of look different but you know the

1103
00:47:03,318 --> 00:47:08,088
physics is very different with the

1104
00:47:04,760 --> 00:47:11,270
velocities and that's in the gas

1105
00:47:08,088 --> 00:47:12,349
expansion okay great point so I'm gonna

1106
00:47:11,269 --> 00:47:14,030
read this question but I'm going to

1107
00:47:12,349 --> 00:47:16,220
expand it just a little bit because it's

1108
00:47:14,030 --> 00:47:18,380
a really good one and through Parian is

1109
00:47:16,219 --> 00:47:20,750
asking about whether Betelgeuse when it

1110
00:47:18,380 --> 00:47:23,780
goes would it make LIGO wobble and I'm

1111
00:47:20,750 --> 00:47:27,739
going to expand that to say do super

1112

00:47:23,780 --> 00:47:32,720
novae create gravitational waves that's

1113
00:47:27,739 --> 00:47:35,088
a great question and I think that in

1114
00:47:32,719 --> 00:47:36,949
theory they do that this this huge

1115
00:47:35,088 --> 00:47:38,960
change in gravity as you're gonna

1116
00:47:36,949 --> 00:47:41,809
collapse from something the size of the

1117
00:47:38,960 --> 00:47:44,720
earth to ten kilometers down and a

1118
00:47:41,809 --> 00:47:46,779
neutron star you expect a large amount

1119
00:47:44,719 --> 00:47:49,939
of gravitational waves to be emitted

1120
00:47:46,780 --> 00:47:56,150
whether or not Lego will detect that as

1121
00:47:49,940 --> 00:47:58,639
another question so I I think that what

1122
00:47:56,150 --> 00:48:01,150
they've seen already with the merger of

1123
00:47:58,639 --> 00:48:04,000
black holes is something they're kind of

1124
00:48:01,150 --> 00:48:05,869
very tuned for it it produces

1125
00:48:04,000 --> 00:48:10,099
wavelengths of gravitational radiation

1126
00:48:05,869 --> 00:48:13,010

that are fairly narrow and and then it

1127

00:48:10,099 --> 00:48:15,230

gets as they merge it gets higher and

1128

00:48:13,010 --> 00:48:17,900

higher frequency but a very narrow range

1129

00:48:15,230 --> 00:48:22,088

of frequencies think of a supernova

1130

00:48:17,900 --> 00:48:24,829

explosion as more like I know throwing

1131

00:48:22,088 --> 00:48:28,960

spaghetti against the wall you're going

1132

00:48:24,829 --> 00:48:31,910

to get a whole range a whole range of

1133

00:48:28,960 --> 00:48:33,889

frequencies of gravitational radiation

1134

00:48:31,909 --> 00:48:36,469

and that's going to make it actually

1135

00:48:33,889 --> 00:48:39,440

harder to detect than the narrow range

1136

00:48:36,469 --> 00:48:42,068

of frequencies we saw with the black

1137

00:48:39,440 --> 00:48:42,068

hole mergers

1138

00:48:42,280 --> 00:48:46,610

but-but-but built on that there is a

1139

00:48:44,780 --> 00:48:48,980

there's a recent study from a friend of

1140

00:48:46,610 --> 00:48:50,059

a colleague of mine who with the

1141
00:48:48,980 --> 00:48:52,579
discovery of gravitational waves

1142
00:48:50,059 --> 00:48:54,289
calculated what a type 1a supernova

1143
00:48:52,579 --> 00:48:56,840
would do for gravitational waves because

1144
00:48:54,289 --> 00:48:59,420
there we believe it's some in some cases

1145
00:48:56,840 --> 00:49:00,650
two white dwarfs that come together to

1146
00:48:59,420 --> 00:49:02,930
blow up and this is something our

1147
00:49:00,650 --> 00:49:05,150
previous Kepler study showed and what

1148
00:49:02,929 --> 00:49:06,859
they saw is not that LIGO would be able

1149
00:49:05,150 --> 00:49:10,610
to see it but the next generation of

1150
00:49:06,860 --> 00:49:13,220
gravitational waves a close enough star

1151
00:49:10,610 --> 00:49:16,430
in a type 1a supernova so kind of within

1152
00:49:13,219 --> 00:49:19,129
our local neighborhood could be detected

1153
00:49:16,429 --> 00:49:21,739
by gravitational waves from a type 1a

1154
00:49:19,130 --> 00:49:23,930
thermonuclear supernova so it gives us

1155
00:49:21,739 --> 00:49:25,699
another way to look for these things you

1156
00:49:23,929 --> 00:49:27,379
know I'm looking for the day we can see

1157
00:49:25,699 --> 00:49:29,179
the neutrinos the gravitational waves

1158
00:49:27,380 --> 00:49:31,280
and the shockwave all from the same

1159
00:49:29,179 --> 00:49:36,919
explosion you just don't need much to

1160
00:49:31,280 --> 00:49:38,720
you so yeah that would be please okay so

1161
00:49:36,920 --> 00:49:41,630
gravitational waves two neutrinos the

1162
00:49:38,719 --> 00:49:46,219
whole gambit yeah it's from Twitter at

1163
00:49:41,630 --> 00:49:49,280
tra hall a TDR TRW well nevermind it so

1164
00:49:46,219 --> 00:49:50,569
I can't pronounce it he's asking what

1165
00:49:49,280 --> 00:49:53,480
does this data mean for our

1166
00:49:50,570 --> 00:49:55,760
understanding of black holes I mean can

1167
00:49:53,480 --> 00:49:57,219
you go through Kepler data and do that

1168
00:49:55,760 --> 00:49:59,960
doing an analysis for maybe

1169

00:49:57,219 --> 00:50:01,429
understanding black holes at all because

1170
00:49:59,960 --> 00:50:07,010
you've already done some core collapse

1171
00:50:01,429 --> 00:50:09,289
stuff so my my feeling is that we you

1172
00:50:07,010 --> 00:50:14,150
know we we could do that if we had many

1173
00:50:09,289 --> 00:50:16,070
many supernovae in the data set but with

1174
00:50:14,150 --> 00:50:18,680
the handful of supernovae that we have

1175
00:50:16,070 --> 00:50:20,510
most of them are going to be producing

1176
00:50:18,679 --> 00:50:24,319
they're mostly going to be lower mass

1177
00:50:20,510 --> 00:50:28,760
stars so a solar masses 215 solar masses

1178
00:50:24,320 --> 00:50:30,710
and generating neutron stars to have a

1179
00:50:28,760 --> 00:50:33,860
chance of seeing stars that produce the

1180
00:50:30,710 --> 00:50:38,059
black holes I think because those stars

1181
00:50:33,860 --> 00:50:41,450
are more rare those massive 30 50 solar

1182
00:50:38,059 --> 00:50:44,869
mass stars I think we're going to need a

1183
00:50:41,449 --> 00:50:47,269

much larger data set of Kepler supernova

1184

00:50:44,869 --> 00:50:50,929

this is kind of where k2 comes and we

1185

00:50:47,269 --> 00:50:54,050

have been looking at supernovae with k2

1186

00:50:50,929 --> 00:50:57,230

and we have several new supernovae

1187

00:50:54,050 --> 00:50:58,970

in that dataset and and so you know if

1188

00:50:57,230 --> 00:51:01,550

we could continue with that that would

1189

00:50:58,969 --> 00:51:02,689

be that would be great well since you

1190

00:51:01,550 --> 00:51:05,119

brought that up I want to go ahead and

1191

00:51:02,690 --> 00:51:07,400

cover you're a part of a group it says

1192

00:51:05,119 --> 00:51:10,550

here that is called the Kepler extra

1193

00:51:07,400 --> 00:51:15,320

galactic survey or and this is one of

1194

00:51:10,550 --> 00:51:18,769

the coolest acronyms ever Keggs rad come

1195

00:51:15,320 --> 00:51:38,090

up with that yeah you're the co I'm not

1196

00:51:18,769 --> 00:51:39,469

surprised that's right so tell us a

1197

00:51:38,090 --> 00:51:41,329

little bit about that what are you guys

1198
00:51:39,469 --> 00:51:44,779
doing at kegs besides looking for five

1199
00:51:41,329 --> 00:51:47,029
o'clock and is this an extension and

1200
00:51:44,780 --> 00:51:48,890
that you know Kepler has been expanded

1201
00:51:47,030 --> 00:51:52,880
to do looking in other parts of the sky

1202
00:51:48,889 --> 00:51:55,489
now so tell us what about kegs so you

1203
00:51:52,880 --> 00:51:57,590
know as Peter said originally Peter and

1204
00:51:55,489 --> 00:52:00,649
I had this 100 galaxies were monitoring

1205
00:51:57,590 --> 00:52:02,420
and then we met these uh the guys from

1206
00:52:00,650 --> 00:52:03,710
Maryland who were doing a few hundred

1207
00:52:02,420 --> 00:52:05,990
galaxies and that's how we did these

1208
00:52:03,710 --> 00:52:07,280
originally with Kepler so we said hey

1209
00:52:05,989 --> 00:52:09,259
it'd be great me both want the same

1210
00:52:07,280 --> 00:52:12,440
things we both want to study galaxies

1211
00:52:09,260 --> 00:52:14,450
why don't we do this with k2o and it's

1212
00:52:12,440 --> 00:52:16,909
actually formed an integral part of k2

1213
00:52:14,449 --> 00:52:20,089
and it's actually very beneficial to k2

1214
00:52:16,909 --> 00:52:21,769
so as you said Kepler stared at the same

1215
00:52:20,090 --> 00:52:25,269
patch of sky for about five years in

1216
00:52:21,769 --> 00:52:27,769
about Cygnus now because of the

1217
00:52:25,269 --> 00:52:30,469
partially broken wheels that forced

1218
00:52:27,769 --> 00:52:33,079
Kepler to point it changes fields every

1219
00:52:30,469 --> 00:52:34,819
85 days and so it looks along the

1220
00:52:33,079 --> 00:52:38,960
ecliptic along the plane of the solar

1221
00:52:34,820 --> 00:52:41,180
system and what happens is every 85 days

1222
00:52:38,960 --> 00:52:42,650
it looks towards the Milky Way so

1223
00:52:41,179 --> 00:52:44,839
towards the Milky Way where there's lots

1224
00:52:42,650 --> 00:52:47,240
of stars to look for stellar

1225
00:52:44,840 --> 00:52:49,490
astrophysics planets but then it looks

1226

00:52:47,239 --> 00:52:51,589
the other 85 days it rotates and it

1227
00:52:49,489 --> 00:52:53,419
looks away from the Milky Way where

1228
00:52:51,590 --> 00:52:55,309
there's not a lot of stars but when you

1229
00:52:53,420 --> 00:52:58,369
look away from the Milky Way you look

1230
00:52:55,309 --> 00:53:01,070
and see lots of galaxies so roughly

1231
00:52:58,369 --> 00:53:03,890
every other field is what we call a

1232
00:53:01,070 --> 00:53:07,820
Keggs field so it's every hour of their

1233
00:53:03,889 --> 00:53:10,519
85 days we monitor about 3,000

1234
00:53:07,820 --> 00:53:12,530
Galaxy so instead of 500 were monitoring

1235
00:53:10,519 --> 00:53:15,980
thousands of galaxies to find this

1236
00:53:12,530 --> 00:53:19,519
because of the power of k2 and Kepler so

1237
00:53:15,980 --> 00:53:24,170
to date we've monitored nearly 22,000

1238
00:53:19,519 --> 00:53:26,269
galaxies with k2 and we found a number

1239
00:53:24,170 --> 00:53:29,240
of supernovae were we're racking up

1240
00:53:26,269 --> 00:53:31,519

supernova fast faster than we can we can

1241

00:53:29,239 --> 00:53:33,319

think about and we have we're in the

1242

00:53:31,519 --> 00:53:34,699

process of working on lots of cool new

1243

00:53:33,320 --> 00:53:37,910

discoveries that you know we hope to

1244

00:53:34,699 --> 00:53:41,089

talk about and maybe future hangouts and

1245

00:53:37,909 --> 00:53:44,089

it's because of this this of this power

1246

00:53:41,090 --> 00:53:46,640

of continuously monitoring we can probe

1247

00:53:44,090 --> 00:53:49,340

these other things so you really do have

1248

00:53:46,639 --> 00:53:55,849

more data on supernovae then I mean you

1249

00:53:49,340 --> 00:53:58,640

guys rock we did we we we have that's

1250

00:53:55,849 --> 00:53:59,809

amazing we're blowing everything out of

1251

00:53:58,639 --> 00:54:02,119

the water and it's quite interesting

1252

00:53:59,809 --> 00:54:06,579

Kepler start as a planetary mission but

1253

00:54:02,119 --> 00:54:06,579

now we're doing cosmology with Kepler

1254

00:54:07,030 --> 00:54:12,920

you know imagine you know I know it's

1255
00:54:11,510 --> 00:54:14,510
really been really really remarkable

1256
00:54:12,920 --> 00:54:16,130
well I got a couple more personal needs

1257
00:54:14,510 --> 00:54:19,670
over at a time we only have a few more

1258
00:54:16,130 --> 00:54:22,579
minutes at Joel Edwards is asking about

1259
00:54:19,670 --> 00:54:27,050
V Y Canis Majoris one of our favorite

1260
00:54:22,579 --> 00:54:29,269
hyper Nobby candidates we need this is a

1261
00:54:27,050 --> 00:54:30,710
very very large star and when it does go

1262
00:54:29,269 --> 00:54:38,300
will it leave a black hole or a neutron

1263
00:54:30,710 --> 00:54:43,659
star while you're at it you got two

1264
00:54:38,300 --> 00:54:43,660
three minutes that might be the decision

1265
00:54:44,690 --> 00:54:50,619
we believe that obviously large storms

1266
00:54:47,659 --> 00:54:53,449
like V Y Canis Major could be you know a

1267
00:54:50,619 --> 00:54:55,460
class called luminous blue variable and

1268
00:54:53,449 --> 00:54:57,230
these are stars that actually have

1269
00:54:55,460 --> 00:54:59,809
fooled us into previous supernova

1270
00:54:57,230 --> 00:55:02,119
explosions and so when we say really

1271
00:54:59,809 --> 00:55:04,699
hypernova we just mean a big supernova

1272
00:55:02,119 --> 00:55:06,949
and as Peter pointed out the larger

1273
00:55:04,699 --> 00:55:08,659
stars on we do believe create black

1274
00:55:06,949 --> 00:55:10,699
holes there's even a new theory that

1275
00:55:08,659 --> 00:55:12,649
with the very earliest stars that are a

1276
00:55:10,699 --> 00:55:13,730
couple thousand solar masses we could

1277
00:55:12,650 --> 00:55:15,980
see this with the James Webb Space

1278
00:55:13,730 --> 00:55:19,070
Telescope and in fact we can get a

1279
00:55:15,980 --> 00:55:21,409
supernova that is 50,000 times the mass

1280
00:55:19,070 --> 00:55:24,230
of our Sun so we are looking we

1281
00:55:21,409 --> 00:55:26,569
we'll look for those things but you know

1282
00:55:24,230 --> 00:55:28,940
in hypernova it's essentially the same

1283

00:55:26,570 --> 00:55:30,410
kind of gamut we now have a new class of

1284
00:55:28,940 --> 00:55:33,110
supernovae called superluminous

1285
00:55:30,409 --> 00:55:35,210
supernova and very apt description oh

1286
00:55:33,110 --> 00:55:40,670
we're talking about we see something and

1287
00:55:35,210 --> 00:55:42,650
we just call it what we see it it's

1288
00:55:40,670 --> 00:55:45,050
these are orders of magnitude brighter

1289
00:55:42,650 --> 00:55:47,150
than our current supernovae that we kind

1290
00:55:45,050 --> 00:55:49,039
of came out of nowhere so you know we'll

1291
00:55:47,150 --> 00:55:53,059
probably have hyper superluminous

1292
00:55:49,039 --> 00:55:54,949
supernova in the near future believe

1293
00:55:53,059 --> 00:55:57,259
these are a couple hundred solar mass

1294
00:55:54,949 --> 00:55:59,929
stars that explode so we do believe if

1295
00:55:57,260 --> 00:56:01,640
it blows up it it would create it and it

1296
00:55:59,929 --> 00:56:07,789
would probably create a black hole the

1297
00:56:01,639 --> 00:56:10,159

size we don't know in celebration of

1298

00:56:07,789 --> 00:56:12,320

spring and baseball where we're batting

1299

00:56:10,159 --> 00:56:17,170

a thousand with people who want Jacob

1300

00:56:12,320 --> 00:56:17,170

pissed all our hangout participants

1301

00:56:18,849 --> 00:56:28,369

Moray just the universe which are very

1302

00:56:26,030 --> 00:56:30,769

hot and large and they burn very bright

1303

00:56:28,369 --> 00:56:32,599

and not for very long so interesting

1304

00:56:30,769 --> 00:56:35,480

stars so one more one more comment here

1305

00:56:32,599 --> 00:56:37,880

Christopher Patterson is asking how come

1306

00:56:35,480 --> 00:56:39,800

the core collapse of a type 2 supernova

1307

00:56:37,880 --> 00:56:41,930

is so sudden why don't we see a more

1308

00:56:39,800 --> 00:56:44,300

gradual collapse as the star burns less

1309

00:56:41,929 --> 00:56:45,980

and less fuel and the iron starts to

1310

00:56:44,300 --> 00:56:48,590

pile up that's a good question how come

1311

00:56:45,980 --> 00:56:51,500

it happen so fast it is a good question

1312
00:56:48,590 --> 00:56:55,280
and and I just I've been talking to this

1313
00:56:51,500 --> 00:56:58,090
about my to my students now and it is

1314
00:56:55,280 --> 00:57:01,970
it's funny that the hydrogen burns two

1315
00:56:58,090 --> 00:57:04,100
fuses the helium and this takes a long

1316
00:57:01,969 --> 00:57:06,559
time and then that every step actually

1317
00:57:04,099 --> 00:57:10,900
takes shorter and shorter so the fusion

1318
00:57:06,559 --> 00:57:15,199
to from silicon iron actually takes a

1319
00:57:10,900 --> 00:57:17,990
less than a day and as you build up this

1320
00:57:15,199 --> 00:57:21,259
iron core it's actually supported by the

1321
00:57:17,989 --> 00:57:23,029
same thing that supports white dwarf

1322
00:57:21,260 --> 00:57:25,310
stars it's called electron degeneracy

1323
00:57:23,030 --> 00:57:27,019
it's a quantum mechanical effect that

1324
00:57:25,309 --> 00:57:28,340
that electrons don't like to get too

1325
00:57:27,019 --> 00:57:31,309
close together and they produce a

1326
00:57:28,340 --> 00:57:35,039
pressure but once that iron core reaches

1327
00:57:31,309 --> 00:57:37,259
a size of around 1.4 solar masses

1328
00:57:35,039 --> 00:57:39,420
that that pressure can't hold it up

1329
00:57:37,260 --> 00:57:42,870
anymore and it collapses down in a very

1330
00:57:39,420 --> 00:57:45,780
sudden collapse and and produces all of

1331
00:57:42,869 --> 00:57:47,969
us this the neutrinos and and and the

1332
00:57:45,780 --> 00:57:51,480
bounce and and everything that we see so

1333
00:57:47,969 --> 00:57:53,909
it it is a very quick thing that happens

1334
00:57:51,480 --> 00:57:56,190
and and that's probably why we get the

1335
00:57:53,909 --> 00:57:59,670
the explosions that we see is it really

1336
00:57:56,190 --> 00:58:02,369
needs to be quite fast to explode the

1337
00:57:59,670 --> 00:58:04,500
stars all right well this is Grayson on

1338
00:58:02,369 --> 00:58:07,500
well thank you very much and this has

1339
00:58:04,500 --> 00:58:10,920
been a really great great yeah I want to

1340

00:58:07,500 --> 00:58:12,630
thank you both for taking the time your

1341
00:58:10,920 --> 00:58:17,190
discovery so when you get more supernova

1342
00:58:12,630 --> 00:58:19,680
data will you come back you bet they'll

1343
00:58:17,190 --> 00:58:24,990
give you a hard time but not I just want

1344
00:58:19,679 --> 00:58:26,309
to make sure we're still gonna make you

1345
00:58:24,989 --> 00:58:28,439
and I have known each other a long time

1346
00:58:26,309 --> 00:58:29,940
so you know that we will neutrally make

1347
00:58:28,440 --> 00:58:31,380
fun of each other so there's even things

1348
00:58:29,940 --> 00:58:38,869
out we need to do it at 4:00 in the

1349
00:58:31,380 --> 00:58:41,700
morning let's not forget the kegs

1350
00:58:38,869 --> 00:58:43,679
toriana I'll just stay up because it'll

1351
00:58:41,699 --> 00:58:45,409
be 1 a.m. here I'll just stay up all

1352
00:58:43,679 --> 00:58:49,919
night yeah good idea

1353
00:58:45,409 --> 00:58:52,019
absolutely okay thank you really enjoyed

1354
00:58:49,920 --> 00:58:53,760

it thank you so that is the end of this

1355

00:58:52,019 --> 00:58:55,230

one and we want to I think Carol we've

1356

00:58:53,760 --> 00:59:01,320

got a couple lined up now don't wait

1357

00:58:55,230 --> 00:59:06,500

what do we have okay Hubble's fans you

1358

00:59:01,320 --> 00:59:11,220

know what your kids the anniversary

1359

00:59:06,500 --> 00:59:12,809

about the anniversary every so we'll

1360

00:59:11,219 --> 00:59:15,000

have the Hubble anniversary and we'll

1361

00:59:12,809 --> 00:59:17,639

talk about that and we will have maybe

1362

00:59:15,000 --> 00:59:19,949

something nice to look at to discuss

1363

00:59:17,639 --> 00:59:22,199

that awesome great so that'll be next

1364

00:59:19,949 --> 00:59:24,389

weekend yeah you'd have these

1365

00:59:22,199 --> 00:59:26,939

anniversaries is something odd like 26

1366

00:59:24,389 --> 00:59:29,489

and a half anniversary you know that'll

1367

00:59:26,940 --> 00:59:32,240

be you can do that what I can be that

1368

00:59:29,489 --> 00:59:44,669

girlfriend for Hubble like oh it's our

1369
00:59:32,239 --> 00:59:48,379
26th quarter month no I think okay

1370
00:59:44,670 --> 00:59:48,380
anyway that's what we'll do so

1371
00:59:48,568 --> 00:59:53,548
Peter thank you very much Peter gonna

1372
00:59:50,849 --> 00:59:56,579
bitch from the from Notre Dame and Brad

1373
00:59:53,548 --> 01:00:00,630
Tucker thank you both very much thank

1374
00:59:56,579 --> 01:00:02,910
you so much we will see folks next week

1375
01:00:00,630 --> 01:00:05,068
same couple time same channel same

1376
01:00:02,909 --> 01:00:07,199
everything so we will talk to you next

1377
01:00:05,068 --> 01:00:10,969
week thank you all for watching and as

1378
01:00:07,199 --> 01:00:10,969
always keep looking