HUBBLE hangouts

HUBBLE 25

April 14, 2016 3pm EDT

Caught in the Act: Discovery of a supernova as it explodes

1
00:00:04,910 --> 00:00:02,810
nope hello everybody and welcome to this

2
00:00:07,730 --> 00:00:04,920
week's Hubbell hangout my name is Tony

3
00:00:09,200 --> 00:00:07,740
Darnell and I am your host for this I

4
00:00:10,549 --> 00:00:09,210
think is one of one of our better

5
00:00:11,209 --> 00:00:10,559
hangouts we got a really exciting one

6
00:00:12,799 --> 00:00:11,219
planned for you

7
00:00:14,150 --> 00:00:12,809
you know I say that but you know every

8
00:00:15,560 --> 00:00:14,160
week they're all great aren't they I

9
00:00:17,779 --> 00:00:15,570
mean I think all of our Hubbell hangouts

10
00:00:19,519 --> 00:00:17,789
are awesome so this week we're going to

11
00:00:21,890 --> 00:00:19,529
be talking with astronomers who've used

12
00:00:24,259 --> 00:00:21,900
data from the Kepler space telescope to

13
00:00:26,060 --> 00:00:24,269

discover the precursor of or have

14
00:00:28,820 --> 00:00:26,070
observed for the first time a precursor

15
00:00:30,769 --> 00:00:28,830
of a supernova in Kepler data and we're

16
00:00:33,020 --> 00:00:30,779
going to talk about why that's important

17
00:00:35,569 --> 00:00:33,030
what they did and what kind how they use

18
00:00:37,250 --> 00:00:35,579
the Kepler data itself to to find these

19
00:00:39,440 --> 00:00:37,260
things because this is also something

20
00:00:41,600 --> 00:00:39,450
that is very important in astronomy

21
00:00:44,510 --> 00:00:41,610
these days using archives to do science

22
00:00:46,190 --> 00:00:44,520
and research so an international science

23
00:00:48,920 --> 00:00:46,200
team which is led by dr. Peter garnet

24
00:00:52,610 --> 00:00:48,930
ovitch at the she at the University of

25
00:00:54,319 --> 00:00:52,620
Notre Dame in Indiana they led the team

26
00:00:56,660 --> 00:00:54,329
that captured and analyzed light from

27
00:00:59,000 --> 00:00:56,670
Kepler over a three-year period that

28
00:01:01,760 --> 00:00:59,010
studied 500 distant galaxies searching

29
00:01:03,979 --> 00:01:01,770
some 50 trillion stars and they were

30
00:01:06,410 --> 00:01:03,989
hunting for signs of this stellar death

31
00:01:08,330 --> 00:01:06,420
explosion known as supernovae and I read

32
00:01:09,620 --> 00:01:08,340
that straight from the press release

33
00:01:11,030 --> 00:01:09,630
because I wanted to get it right so

34
00:01:15,320 --> 00:01:11,040
anyway we're going to tell him with

35
00:01:18,050 --> 00:01:15,330
Peter as well as his colleague from

36
00:01:19,760 --> 00:01:18,060
Australia who went through a lot of

37
00:01:21,920 --> 00:01:19,770
trouble to be with us here today so he's

38
00:01:25,760 --> 00:01:21,930

gotten up very early in the morning or

39
00:01:27,560 --> 00:01:25,770
Brad is 5 o'clock in the morning before

40
00:01:29,870 --> 00:01:27,570
I introduce you properly I have to say

41
00:01:33,020 --> 00:01:29,880
hello to my co-host dr. Carol Christian

42
00:01:34,999 --> 00:01:33,030
the HST that's Hubble Space Telescope

43
00:01:37,219 --> 00:01:35,009
for anybody who doesn't know I'll reach

44
00:01:37,760 --> 00:01:37,229
out scientists I Carol it's good to see

45
00:01:40,580 --> 00:01:37,770
you again

46
00:01:43,310 --> 00:01:40,590
hey Tony how are you I'm really good and

47
00:01:44,389 --> 00:01:43,320
also Scott Lewis the he's Hamming all

48
00:01:46,429 --> 00:01:44,399
the social media and driving the

49
00:01:48,560 --> 00:01:46,439
internet and handling our comments and

50
00:01:49,999 --> 00:01:48,570
interacting and posting on social media

51
00:01:53,410 --> 00:01:50,009
so hi Scott it's good to see you how are

52
00:01:57,139 --> 00:01:53,420
you doing I am getting over the plague

53
00:01:59,569 --> 00:01:57,149
thank you big your reasoning out here in

54
00:02:02,480 --> 00:01:59,579
Los Angeles it's underneath space

55
00:02:04,609 --> 00:02:02,490
shuttle Endeavour we had a blast hung

56
00:02:06,039 --> 00:02:04,619
out with Buzz Aldrin and Sam Chris

57
00:02:09,440 --> 00:02:06,049
Bradley

58
00:02:11,930 --> 00:02:09,450
you know he was there also I got to hang

59
00:02:16,370 --> 00:02:11,940
out with Robert Picardo

60
00:02:17,930 --> 00:02:16,380
better known as the doctor yeah but he's

61
00:02:19,810 --> 00:02:17,940
also working with the planet Church

62
00:02:22,310 --> 00:02:19,820
society so we had a really good night

63
00:02:27,020 --> 00:02:22,320

thousands of people there and I got all

64
00:02:30,080 --> 00:02:27,030
their germs so that's worse than being

65
00:02:32,420 --> 00:02:30,090
on an airplane for yeah it's yeah it's

66
00:02:37,010 --> 00:02:32,430
like being at a super super conference

67
00:02:38,960 --> 00:02:37,020
in a very close combined space oh so

68
00:02:43,520 --> 00:02:38,970
that's what space travel would be like

69
00:02:47,060 --> 00:02:43,530
yeah all of all the nerd germs going

70
00:02:49,010 --> 00:02:47,070
around and around and around on jalisa

71
00:02:50,450 --> 00:02:49,020
terms oh geez

72
00:02:53,000 --> 00:02:50,460
well I didn't see some of your Facebook

73
00:02:54,740 --> 00:02:53,010
postings and was okay so I was jealous

74
00:02:56,630 --> 00:02:54,750
but that's okay that's fine all right

75
00:03:06,080 --> 00:02:56,640
it's okay next time I'll call you you

76
00:03:08,210 --> 00:03:06,090
know we we don't have lives we actually

77
00:03:08,510 --> 00:03:08,220
don't have lives but we've gotta lose in

78
00:03:11,630 --> 00:03:08,520
LA

79
00:03:14,420 --> 00:03:11,640
is it you know I'm just but it was for

80
00:03:17,330 --> 00:03:14,430
science so they're also with my JPL

81
00:03:19,760 --> 00:03:17,340
friends so way to boost their up there

82
00:03:22,580 --> 00:03:19,770
so it was great we had a lot of fun

83
00:03:25,270 --> 00:03:22,590
doing science but also partying in

84
00:03:28,400 --> 00:03:25,280
apparently that's the part I saw but I

85
00:03:35,480 --> 00:03:28,410
mean let's be honest here we all know

86
00:03:37,880 --> 00:03:35,490
what competition well this particular

87
00:03:39,790 --> 00:03:37,890
Yuri's Night was kind of kind of a big

88
00:03:42,440 --> 00:03:39,800

one anyway because you guys saw that

89
00:03:44,620 --> 00:03:42,450
breakthrough starshot announcement by

90
00:03:48,260 --> 00:03:44,630
that Russian millionaire billionaire

91
00:03:52,660 --> 00:03:48,270
gonna send little tiny probes to us to

92
00:03:54,770 --> 00:03:52,670
stars and and that back yeah here's

93
00:03:58,460 --> 00:03:54,780
Stephen Hawking and everybody and

94
00:04:00,380 --> 00:03:58,470
animate made kind of a big splash so I

95
00:04:02,420 --> 00:04:00,390
don't know I didn't see that coming that

96
00:04:03,800 --> 00:04:02,430
sort of came out of nowhere for me so I

97
00:04:14,980 --> 00:04:03,810
don't know I don't know anything about

98
00:04:20,330 --> 00:04:18,800
yeah really seriously we can probably

99
00:04:25,460 --> 00:04:20,340
think of other stuff to do with that

100
00:04:25,820 --> 00:04:25,470
money but whatever okay so onto Kepler

101
00:04:28,370 --> 00:04:25,830
so

102
00:04:30,950 --> 00:04:28,380
we want the whole point of these

103
00:04:33,589 --> 00:04:30,960
hangouts folks is to bring the latest

104
00:04:36,439 --> 00:04:33,599
science from Hubble and its sister

105
00:04:37,730 --> 00:04:36,449
missions to you directly and you can

106
00:04:39,260 --> 00:04:37,740
interact and talk with some of the

107
00:04:40,969 --> 00:04:39,270
science some of the scientists who are

108
00:04:43,189 --> 00:04:40,979
doing the research so we want your

109
00:04:44,870 --> 00:04:43,199
questions we want your comments and so

110
00:04:46,279 --> 00:04:44,880
we hope you'll take some time during

111
00:04:48,589 --> 00:04:46,289
this hangout to share with us your

112
00:04:50,480 --> 00:04:48,599
feelings your questions and we'll get to

113
00:04:52,249 --> 00:04:50,490

them but but you need to know how so

114
00:04:54,409 --> 00:04:52,259
Scott why don't you tell people how they

115
00:04:55,850 --> 00:04:54,419
can interact with us well the best way

116
00:04:57,740 --> 00:04:55,860
to interact with us is where I'm seeing

117
00:04:59,960 --> 00:04:57,750
a bunch of people already is in the

118
00:05:02,960 --> 00:04:59,970
YouTube live chat so since we're using

119
00:05:04,850 --> 00:05:02,970
the YouTube live event you can interact

120
00:05:06,230 --> 00:05:04,860
with other people watching the show as

121
00:05:07,760 --> 00:05:06,240
we're doing it live you can ask

122
00:05:10,760 --> 00:05:07,770
questions and I'll be going through

123
00:05:13,040 --> 00:05:10,770
there locking people if I need to which

124
00:05:17,390 --> 00:05:13,050
unfortunately I have so let's try to

125
00:05:19,850 --> 00:05:17,400
keep it on topic but ask us some

126
00:05:21,559 --> 00:05:19,860
questions regarding the the data on on

127
00:05:24,110 --> 00:05:21,569
this Hubble hangout or anything

128
00:05:26,749 --> 00:05:24,120
regarding what we're talking about here

129
00:05:29,240 --> 00:05:26,759
with detecting the the supernova also

130
00:05:31,249 --> 00:05:29,250
we're having the conversation over on

131
00:05:33,980 --> 00:05:31,259
twitter using the hashtag Hubble hangout

132
00:05:36,469 --> 00:05:33,990
so I am live tweeting will be sharing

133
00:05:38,240 --> 00:05:36,479
out some of the imagery and the graphics

134
00:05:40,310 --> 00:05:38,250
that go along with today's hangout any

135
00:05:42,920 --> 00:05:40,320
questions use that hashtag and we'll get

136
00:05:45,110 --> 00:05:42,930
back to you other ways to is we have the

137
00:05:47,450 --> 00:05:45,120
event so opened on Facebook and Google+

138
00:05:48,740 --> 00:05:47,460

so if you do have comments there I will

139
00:05:50,629 --> 00:05:48,750
be going through and taking a look at

140
00:05:52,820 --> 00:05:50,639
them but the the best and easiest way is

141
00:05:55,879 --> 00:05:52,830
on Twitter and directly here on YouTube

142
00:06:05,779 --> 00:05:55,889
uh Scott I just want to say I'm really

143
00:06:07,730 --> 00:06:05,789
glad you know if you need to make a

144
00:06:09,589 --> 00:06:07,740
last-minute phone call late at night is

145
00:06:15,140 --> 00:06:09,599
a three-hour time difference between you

146
00:06:16,430 --> 00:06:15,150
and me I'm still awake alright so yes

147
00:06:19,010 --> 00:06:16,440
and what will happen is Scott's really

148
00:06:21,050 --> 00:06:19,020
good about posting all the relevant

149
00:06:22,999 --> 00:06:21,060
things into a this chat window that we

150
00:06:24,469 --> 00:06:23,009
can see that helps me to get to your

151
00:06:26,719 --> 00:06:24,479
comments so we will get to all of them

152
00:06:28,430 --> 00:06:26,729
as soon as there is if that when there's

153
00:06:30,230 --> 00:06:28,440
time and so please let us have it

154
00:06:31,939 --> 00:06:30,240
bring it on we want to see it so let me

155
00:06:33,860 --> 00:06:31,949
introduce our guests today these are a

156
00:06:35,689 --> 00:06:33,870
couple of astronomers who have been

157
00:06:39,500 --> 00:06:35,699
combing through Kepler data oh I have

158
00:06:43,130 --> 00:06:39,510
with me dr. dr. Peter Gunn

159
00:06:44,570 --> 00:06:43,140
and he is he's the like I said an

160
00:06:46,220 --> 00:06:44,580
astrophysics professor at the University

161
00:06:49,160 --> 00:06:46,230
of Notre Dame and we went through this

162
00:06:51,320 --> 00:06:49,170
also joining me is dr. Brad Tucker he is

163
00:06:54,020 --> 00:06:51,330

a I forgot to ask you before we started

164
00:06:56,600 --> 00:06:54,030
are you a postdoc an associate professor

165
00:06:58,610 --> 00:06:56,610
what are you doing Don I'm a research

166
00:07:00,340 --> 00:06:58,620
fellow Australia you just kind of do

167
00:07:04,250 --> 00:07:00,350
science until you get a permanent job

168
00:07:10,340 --> 00:07:04,260
okay the science you weren't down in

169
00:07:14,120 --> 00:07:12,020
oh and I just want to give a shout out

170
00:07:20,650 --> 00:07:14,130
to Notre Dame my brother went to Notre

171
00:07:29,210 --> 00:07:25,810
I know it's Notre Dame and I'm not even

172
00:07:48,650 --> 00:07:29,220
I'm not gonna show you that green stuff

173
00:07:55,010 --> 00:07:48,660
I have everywhere Notre Dame that means

174
00:07:56,270 --> 00:07:55,020
right Notre Dame okay so so so Peter

175
00:07:57,500 --> 00:07:56,280
let's start with you give us some a

176
00:08:00,080 --> 00:07:57,510
little background on what you were

177
00:08:01,670 --> 00:08:00,090
trying to do what your what your main

178
00:08:06,890 --> 00:08:01,680
interest was studying in and what you

179
00:08:09,920 --> 00:08:06,900
found using Kepler data so Kepler really

180
00:08:12,440 --> 00:08:09,930
was designed to look for planets so it

181
00:08:14,840 --> 00:08:12,450
would focus on stars in our galaxy and

182
00:08:18,380 --> 00:08:14,850
look for little dips as planets went in

183
00:08:21,110 --> 00:08:18,390
front but it focused on about a hundred

184
00:08:23,720 --> 00:08:21,120
square degrees on the sky and people who

185
00:08:25,550 --> 00:08:23,730
study supernovas like Brad and I thought

186
00:08:27,890 --> 00:08:25,560
you know there are galaxies in that

187
00:08:31,310 --> 00:08:27,900
field as well and we can look at those

188
00:08:34,070 --> 00:08:31,320

galaxies and just wait and hope that a

189
00:08:36,409 --> 00:08:34,080
supernova will go off and our initial

190
00:08:39,380 --> 00:08:36,419
proposals were kind of modest we we

191
00:08:43,070 --> 00:08:39,390
asked for about a hundred galaxies to

192
00:08:45,590 --> 00:08:43,080
follow and then rule of thumb is you get

193
00:08:47,420 --> 00:08:45,600
a bout of supernovae every hundred years

194
00:08:50,170 --> 00:08:47,430
in a galaxy so we thought we would get

195
00:08:51,800 --> 00:08:50,180
me one supernova per year in our

196
00:08:54,110 --> 00:08:51,810
proposals

197
00:08:55,400 --> 00:08:54,120
so I have a quote I have a question

198
00:08:59,090 --> 00:08:55,410
because I remember because we have the

199
00:09:02,210 --> 00:08:59,100
archived data for Kepler so initially

200
00:09:05,179 --> 00:09:02,220
that opportunity was not open to the

201
00:09:08,329 --> 00:09:05,189
community right so at first that that

202
00:09:10,069 --> 00:09:08,339
and then there was a Geo program or

203
00:09:13,009 --> 00:09:10,079
something and then at that time you

204
00:09:15,559 --> 00:09:13,019
could request specific things to look at

205
00:09:18,769 --> 00:09:15,569
is that how it worked yeah so I think by

206
00:09:20,569 --> 00:09:18,779
the second cycle there was a Geo program

207
00:09:23,119 --> 00:09:20,579
and we could we could ask for whatever

208
00:09:25,939 --> 00:09:23,129
pixels were remaining because although

209
00:09:26,960 --> 00:09:25,949
it has a hundred square degree field the

210
00:09:29,629 --> 00:09:26,970
number of pixels that can actually

211
00:09:32,239 --> 00:09:29,639
download and send to the earth is is

212
00:09:34,369 --> 00:09:32,249
much much smaller than that so it's real

213
00:09:36,110 --> 00:09:34,379

that's right and so they had picked out

214
00:09:38,629 --> 00:09:36,120
the stars they wanted to monitor and

215
00:09:40,460 --> 00:09:38,639
then they said okay now you some of you

216
00:09:45,199 --> 00:09:40,470
can have the other pixels right there

217
00:09:47,090 --> 00:09:45,209
are like a thousand other stars or other

218
00:09:47,749 --> 00:09:47,100
objects you could you could download as

219
00:09:51,530 --> 00:09:47,759
well

220
00:09:54,439 --> 00:09:51,540
there was a competitive okay call for

221
00:09:59,569 --> 00:09:54,449
that and and so we put in a proposal and

222
00:10:02,240 --> 00:09:59,579
we got our hundred galaxies and so in

223
00:10:05,179 --> 00:10:02,250
parallel and unknown to us Brad and I

224
00:10:06,350 --> 00:10:05,189
were on this original proposal there was

225
00:10:09,170 --> 00:10:06,360
a group at the University of Maryland

226
00:10:11,650 --> 00:10:09,180
that was interested in a GN active

227
00:10:14,629 --> 00:10:11,660
galactic nuclei these are accreting

228
00:10:16,970 --> 00:10:14,639
supermassive black holes and they

229
00:10:19,179 --> 00:10:16,980
produced variability in the cores of

230
00:10:21,980 --> 00:10:19,189
galaxies and they wanted to study this

231
00:10:24,860 --> 00:10:21,990
with with Kepler so they actually put in

232
00:10:27,139 --> 00:10:24,870
four times more galaxies and we did we

233
00:10:28,939 --> 00:10:27,149
were kind of a little tentative and they

234
00:10:31,999 --> 00:10:28,949
thought all this go all out and we'll do

235
00:10:34,850 --> 00:10:32,009
400 galaxies so in the end we combined

236
00:10:37,189 --> 00:10:34,860
all our galaxies together and they ended

237
00:10:38,990 --> 00:10:37,199
up finding supernovae in their galaxies

238
00:10:41,740 --> 00:10:39,000

we didn't find any supernovae in our

239
00:10:45,230 --> 00:10:41,750
galaxies but it all worked out well we

240
00:10:49,970 --> 00:10:45,240
collaborated on this whole thing and not

241
00:10:51,110 --> 00:10:49,980
only are we having these core collapse

242
00:10:53,720 --> 00:10:51,120
supernovae that we're talking about

243
00:10:55,790 --> 00:10:53,730
today but we had three type 1a

244
00:10:59,509 --> 00:10:55,800
supernovae thermonuclear explosions that

245
00:11:02,179 --> 00:10:59,519
we we published last year so we actually

246
00:11:03,590 --> 00:11:02,189
have tons of supernovas then type 1 i:r

247
00:11:04,910 --> 00:11:03,600
these standard candles we've talked

248
00:11:06,620 --> 00:11:04,920
about many times before

249
00:11:08,509 --> 00:11:06,630
and other hangouts well I just want to

250
00:11:11,240 --> 00:11:08,519
point out though that what one of the

251
00:11:14,870 --> 00:11:11,250
the largest benefits and one of the

252
00:11:18,379 --> 00:11:14,880
biggest things that Kepler data gives us

253
00:11:20,930 --> 00:11:18,389
is this time sequence of observations

254
00:11:22,400 --> 00:11:20,940
one of the because it looks in only one

255
00:11:24,650 --> 00:11:22,410
area of the sky this is toward the

256
00:11:27,829 --> 00:11:24,660
constellation Cygnus and studying these

257
00:11:29,000 --> 00:11:27,839
stars 160,000 some oddities and careless

258
00:11:31,280 --> 00:11:29,010
pointed this out another hangouts and

259
00:11:33,110 --> 00:11:31,290
another venues where you need a time

260
00:11:35,480 --> 00:11:33,120
series of the same you need a lot of

261
00:11:37,519 --> 00:11:35,490
observations of the same thing to

262
00:11:38,960 --> 00:11:37,529
capture these dips and brightness as the

263
00:11:41,689 --> 00:11:38,970

planet moves in front of its host star

264
00:11:43,879 --> 00:11:41,699
but that and as Peter just pointed out

265
00:11:46,400 --> 00:11:43,889
we can also that lends itself to other

266
00:11:49,310 --> 00:11:46,410
kinds of science where you need a lot of

267
00:11:51,800 --> 00:11:49,320
images in sequence and so Kepler takes

268
00:11:53,660 --> 00:11:51,810
and so if there was one blip in

269
00:11:57,519 --> 00:11:53,670
brightness you could write a paper on

270
00:12:00,379 --> 00:11:57,529
that but but we would laugh at you so

271
00:12:02,480 --> 00:12:00,389
you actually have to have it something

272
00:12:05,449 --> 00:12:02,490
you hope that it repeats now some

273
00:12:08,000 --> 00:12:05,459
objects like a supernova I'm gonna

274
00:12:09,500 --> 00:12:08,010
repeat but you have to make sure that as

275
00:12:11,660 --> 00:12:09,510
the observations go that you're looking

276
00:12:13,759 --> 00:12:11,670
at a real phenomenon and it and that's

277
00:12:15,980 --> 00:12:13,769
hard when these things are transient I

278
00:12:18,889 --> 00:12:15,990
mean so that's why we have an archive is

279
00:12:20,360 --> 00:12:18,899
because because we archive the data and

280
00:12:23,569 --> 00:12:20,370
the hope is that people will comb

281
00:12:26,210 --> 00:12:23,579
through that data for a while and and

282
00:12:28,430 --> 00:12:26,220
maybe find other things as well I mean

283
00:12:30,259 --> 00:12:28,440
one of the good examples of the scale of

284
00:12:32,750 --> 00:12:30,269
what Kepler does with this time series

285
00:12:35,060 --> 00:12:32,760
is the five supernovae so these two core

286
00:12:37,220 --> 00:12:35,070
collapse plus the three one A's that

287
00:12:39,380 --> 00:12:37,230
Peter talked about in a previous paper

288
00:12:42,290 --> 00:12:39,390

the the amount of data and the data

289
00:12:44,660 --> 00:12:42,300
points we have in these five are more

290
00:12:46,540 --> 00:12:44,670
than all other supernova observations of

291
00:12:49,340 --> 00:12:46,550
all other supernovae ever observed

292
00:12:51,380 --> 00:12:49,350
that's wrong that's a really good thing

293
00:12:53,389 --> 00:12:51,390
so if you think of all of the thousands

294
00:12:54,740 --> 00:12:53,399
of supernovae we have more data on our

295
00:12:56,860 --> 00:12:54,750
five with Kepler than all of those

296
00:12:59,960 --> 00:12:56,870
because of the time cadence it takes

297
00:13:01,879 --> 00:12:59,970
Nativity 30 minutes right or so that's

298
00:13:15,350 --> 00:13:01,889
when you get a new image so that's right

299
00:13:17,389 --> 00:13:15,360
it actually is also nice because even

300
00:13:18,639 --> 00:13:17,399
though you know every 30 minutes is all

301
00:13:21,009 --> 00:13:18,649
probably a little too much for

302
00:13:23,889 --> 00:13:21,019
something that takes months to go up and

303
00:13:27,369 --> 00:13:23,899
down we can actually average that data

304
00:13:32,350 --> 00:13:27,379
together and improve the quality of any

305
00:13:34,540 --> 00:13:32,360
you know 24-hour observation is the sum

306
00:13:36,730 --> 00:13:34,550
of all these half an hour observation so

307
00:13:38,829 --> 00:13:36,740
we actually can beat the noise down and

308
00:13:40,929 --> 00:13:38,839
observe things fainter than other people

309
00:13:42,759 --> 00:13:40,939
could with Kepler that's right because I

310
00:13:44,199 --> 00:13:42,769
mean you do you need a rapid time

311
00:13:46,900 --> 00:13:44,209
sequence for if you're trying to measure

312
00:13:48,369 --> 00:13:46,910
a light transit or a tri light curve of

313
00:13:50,199 --> 00:13:48,379

a transiting planet that might be close

314
00:13:52,030 --> 00:13:50,209
to a star that might do it in only a few

315
00:13:53,530 --> 00:13:52,040
hours you want to get a lot of data

316
00:13:55,749 --> 00:13:53,540
points but in the case of supernova

317
00:13:57,429 --> 00:13:55,759
studies you can actually add them up and

318
00:13:59,799 --> 00:13:57,439
that's a valuable technique in astronomy

319
00:14:02,470 --> 00:13:59,809
where you can take two different

320
00:14:04,900 --> 00:14:02,480
exposures and add them together and get

321
00:14:06,910 --> 00:14:04,910
an image of that is the sum of like

322
00:14:08,410 --> 00:14:06,920
we've had a two 10-second exposure

323
00:14:10,960 --> 00:14:08,420
exposure image you can add them together

324
00:14:13,210 --> 00:14:10,970
to get a 20 second exposure image but

325
00:14:15,249 --> 00:14:13,220
the noise only goes up as the square

326
00:14:18,160 --> 00:14:15,259
root of two so it you get a lot more

327
00:14:20,369 --> 00:14:18,170
signal versus the noise and it's a very

328
00:14:23,949 --> 00:14:20,379
valuable technique that astronomers use

329
00:14:26,470 --> 00:14:23,959
it's a divergent but but this is a

330
00:14:28,869 --> 00:14:26,480
common technique now is to take a lot

331
00:14:31,150 --> 00:14:28,879
all of the data you haven't stack it and

332
00:14:34,299 --> 00:14:31,160
if you do that then you can do

333
00:14:36,129 --> 00:14:34,309
detections and then what you do is you

334
00:14:38,650 --> 00:14:36,139
go back and you look at the individual

335
00:14:41,079 --> 00:14:38,660
exposures for those detections

336
00:14:43,869 --> 00:14:41,089
and that's in fact a really valuable

337
00:14:45,850 --> 00:14:43,879
technique for transients it's also a

338
00:14:47,679 --> 00:14:45,860

valuable technique for looking at high

339
00:14:50,559 --> 00:14:47,689
redshift objects because you can smush

340
00:14:53,019 --> 00:14:50,569
all the data together you search for all

341
00:14:55,030 --> 00:14:53,029
the objects that that have emitted any

342
00:14:57,309 --> 00:14:55,040
light and then you go back and you

343
00:14:59,319 --> 00:14:57,319
measure each color and you see which

344
00:15:01,780 --> 00:14:59,329
one's emitted in the visible and in the

345
00:15:05,049 --> 00:15:01,790
and thread and this caught in this case

346
00:15:07,840 --> 00:15:05,059
instead of color it's time when did it

347
00:15:10,449 --> 00:15:07,850
you know oh we see it but was it here

348
00:15:13,239 --> 00:15:10,459
here here here so it's a really

349
00:15:15,489 --> 00:15:13,249
powerful technique right and in fact

350
00:15:18,609 --> 00:15:15,499
there's probably more supernovae in

351
00:15:20,829 --> 00:15:18,619
these galaxies it's just we've kind of

352
00:15:22,359 --> 00:15:20,839
picked off the low-hanging fruit and

353
00:15:24,850 --> 00:15:22,369
there may be some faint ones that are

354
00:15:27,340 --> 00:15:24,860
very very hard to see and people can you

355
00:15:29,410 --> 00:15:27,350
know add up the points and maybe find a

356
00:15:31,150 --> 00:15:29,420
little little bump there but we've

357
00:15:32,580 --> 00:15:31,160
certainly picked the brightest ones

358
00:15:33,870 --> 00:15:32,590
that'll give us a lot

359
00:15:35,880 --> 00:15:33,880
more information about this tournament

360
00:15:39,630 --> 00:15:35,890
all right so let's get to the to what

361
00:15:40,890 --> 00:15:39,640
you found so the in 2011 you found two

362
00:15:42,900 --> 00:15:40,900
you've already pointed these out two

363
00:15:45,330 --> 00:15:42,910

massive supernovas these were red

364
00:15:46,890 --> 00:15:45,340
supergiant's that exploded while they

365
00:15:49,290 --> 00:15:46,900
were in Kepler's field of view and the

366
00:15:52,290 --> 00:15:49,300
first one was Kate you you have these

367
00:15:56,190 --> 00:15:52,300
really really cozy names real cuddly

368
00:15:59,400 --> 00:15:56,200
ones ksn 2011 a and the other one was

369
00:16:01,170 --> 00:15:59,410
ksn 2011 d tell us a little bit about

370
00:16:02,760 --> 00:16:01,180
the stars themselves and while we're at

371
00:16:05,280 --> 00:16:02,770
it let's go ahead and put up Scott if

372
00:16:08,160 --> 00:16:05,290
you don't mind the light curve of the

373
00:16:09,450 --> 00:16:08,170
supernova itself so we can see what they

374
00:16:12,810 --> 00:16:09,460
looked at and then we're going to talk

375
00:16:14,520 --> 00:16:12,820
about shot breakouts so Peter key Tesla

376
00:16:18,420 --> 00:16:14,530
did about the stars themselves and what

377
00:16:21,240 --> 00:16:18,430
there's these are enormous stars they're

378
00:16:25,380 --> 00:16:21,250
called red supergiant's for a reason the

379
00:16:28,680 --> 00:16:25,390
the radii are 500 sometimes a thousand

380
00:16:31,560 --> 00:16:28,690
times the radius as the Sun so the

381
00:16:33,930 --> 00:16:31,570
Earth's orbit would easily fit in in

382
00:16:36,180 --> 00:16:33,940
these stars and some red supergiant's

383
00:16:39,120 --> 00:16:36,190
even Mars's orbit would easily fit yeah

384
00:16:41,220 --> 00:16:39,130
inside the star so just completely

385
00:16:45,090 --> 00:16:41,230
different scale than what we're used to

386
00:16:47,910 --> 00:16:45,100
and we think of normal stars like like

387
00:16:51,540 --> 00:16:47,920
the Sun and maybe eventually the Sun

388
00:16:52,950 --> 00:16:51,550

will puff up to a red supergiant these

389
00:16:56,430 --> 00:16:52,960
are a little more massive than the Sun

390
00:17:01,140 --> 00:16:56,440
these are are maybe 10 to 15 solar mass

391
00:17:02,430 --> 00:17:01,150
stars evolved running out of hydrogen in

392
00:17:05,010 --> 00:17:02,440
their Center and now they're puffed up

393
00:17:08,310 --> 00:17:05,020
into these into these red supergiant's

394
00:17:08,910 --> 00:17:08,320
and so and but wait a minute okay now

395
00:17:10,230 --> 00:17:08,920
I'm confused

396
00:17:12,960 --> 00:17:10,240
I thought our Sun is gonna be a red

397
00:17:15,720 --> 00:17:12,970
giant and just shed its outer layers and

398
00:17:18,240 --> 00:17:15,730
write it because it's gonna be pretty

399
00:17:20,220 --> 00:17:18,250
big so that's what happens with the more

400
00:17:22,110 --> 00:17:20,230
massive stars as they can become red

401
00:17:23,970 --> 00:17:22,120
supergiant's okay well it's it so you

402
00:17:26,670 --> 00:17:23,980
did that you saw a couple of these and

403
00:17:28,860 --> 00:17:26,680
Scott Scott it up now this well you

404
00:17:32,310 --> 00:17:28,870
explain what are we looking at here so

405
00:17:34,230 --> 00:17:32,320
you know Kepler is relentless every 30

406
00:17:37,620 --> 00:17:34,240
minutes it's it's taking an image and

407
00:17:42,870 --> 00:17:37,630
and we get to make an observation on

408
00:17:46,320 --> 00:17:42,880
that and so as we look on the left side

409
00:17:48,720 --> 00:17:46,330
here we see the three

410
00:17:51,509 --> 00:17:48,730
explosion so we're looking at the at the

411
00:17:54,570 --> 00:17:51,519
galaxy constantly before the explosion

412
00:17:58,789 --> 00:17:54,580
and then in inside that white box

413
00:18:04,560 --> 00:18:01,500

camera flash before it takes a picture

414
00:18:08,250 --> 00:18:04,570
and then that starts to fade and then we

415
00:18:13,980 --> 00:18:08,260
see the rise of supernova itself so this

416
00:18:15,899 --> 00:18:13,990
is the the slower rise is this expanding

417
00:18:19,529 --> 00:18:15,909
envelope of the star itself getting

418
00:18:21,930 --> 00:18:19,539
bigger over time and it takes about in

419
00:18:24,980 --> 00:18:21,940
this case about 13 days for the star to

420
00:18:28,440 --> 00:18:24,990
finally reaches its maximum brightness

421
00:18:31,769 --> 00:18:28,450
and that you know we've seen that before

422
00:18:33,690 --> 00:18:31,779
not in this kind of detail but what we

423
00:18:36,269 --> 00:18:33,700
haven't seen before is that little box

424
00:18:38,789 --> 00:18:36,279
in there where we have what's called a

425
00:18:41,460 --> 00:18:38,799
shock breakouts this is the initial

426
00:18:46,440 --> 00:18:41,470
explosion reaching the surface of this

427
00:18:49,139 --> 00:18:46,450
giant supergiant star and and originally

428
00:18:51,450 --> 00:18:49,149
there was a collapse of the core into a

429
00:18:53,730 --> 00:18:51,460
neutron star probably and that produced

430
00:18:56,490 --> 00:18:53,740
the shockwave which I actually took a

431
00:18:58,799 --> 00:18:56,500
day to reach the surface of the star and

432
00:19:02,779 --> 00:18:58,809
then we see the flash and then the

433
00:19:04,830 --> 00:19:02,789
expanding star yeah I can't see the

434
00:19:05,970 --> 00:19:04,840
x-axis on the because of everybody's

435
00:19:07,950 --> 00:19:05,980
thumbnails and the hang up but I'm

436
00:19:10,080 --> 00:19:07,960
looking at the image now and it shows so

437
00:19:11,399 --> 00:19:10,090
that but that bottom scale is in days in

438
00:19:12,539 --> 00:19:11,409

case I'm just not sure what people are

439
00:19:15,120 --> 00:19:12,549
being able to see when they in the

440
00:19:17,610 --> 00:19:15,130
hangout so it did that little that

441
00:19:19,919 --> 00:19:17,620
little bump there took several hours it

442
00:19:23,129 --> 00:19:19,929
looks like and you said it might have

443
00:19:25,529 --> 00:19:23,139
been due to a core collapse of a into a

444
00:19:28,560 --> 00:19:25,539
neutron star you said so that that's the

445
00:19:31,980 --> 00:19:28,570
the theory of of these kinds of

446
00:19:34,259 --> 00:19:31,990
supernovae massive stars they evolve

447
00:19:36,690 --> 00:19:34,269
they create all all heavier and heavier

448
00:19:39,269 --> 00:19:36,700
elements in their core eventually they

449
00:19:41,639 --> 00:19:39,279
create iron in their core and they can't

450
00:19:46,169 --> 00:19:41,649
get energy out anymore through fusion

451
00:19:47,789 --> 00:19:46,179
and the core will collapse down starting

452
00:19:50,639 --> 00:19:47,799
out maybe the size of the earth

453
00:19:53,460 --> 00:19:50,649
collapsing down to just 10 kilometers in

454
00:19:55,260 --> 00:19:53,470
size as a neutron star and then the rest

455
00:19:57,419 --> 00:19:55,270
of the star kind of bounces off of that

456
00:19:59,590 --> 00:19:57,429
there's a lot of physics we don't

457
00:20:02,420 --> 00:19:59,600
understand at this phase there's

458
00:20:04,910 --> 00:20:02,430
models don't seem to show the ability to

459
00:20:08,690 --> 00:20:04,920
actually explode the star unless there's

460
00:20:10,670 --> 00:20:08,700
extra physics involved including you

461
00:20:13,940 --> 00:20:10,680
know really bizarre exotic stuff like

462
00:20:16,760 --> 00:20:13,950
neutrinos being used to energize the

463
00:20:19,310 --> 00:20:16,770

inner part of the star but eventually a

464
00:20:23,050 --> 00:20:19,320
shock wave gets launched that moves

465
00:20:25,520 --> 00:20:23,060
through this this envelope that's

466
00:20:28,070 --> 00:20:25,530
hundreds of times the radius of the Sun

467
00:20:32,200 --> 00:20:28,080
and we don't even know that's coming

468
00:20:35,240 --> 00:20:32,210
until that flash arrives

469
00:20:36,710 --> 00:20:35,250
well we so we've got the light curve and

470
00:20:37,880 --> 00:20:36,720
we also got a little animation that kind

471
00:20:39,080 --> 00:20:37,890
of shows a little bit about what you're

472
00:20:42,350 --> 00:20:39,090
talking about and while Scott cues that

473
00:20:45,710 --> 00:20:42,360
up I'll just wait before we go there so

474
00:20:48,890 --> 00:20:45,720
so if I understand looking at this graph

475
00:20:51,680 --> 00:20:48,900
there's really no precursor to this it's

476
00:20:53,750 --> 00:20:51,690
just like boom and then it goes right am

477
00:21:00,740 --> 00:20:53,760
i right I mean you could say the shock

478
00:21:04,430 --> 00:21:00,750
breakout is telling you every flash and

479
00:21:06,080 --> 00:21:04,440
the rest of the star expands out and no

480
00:21:09,110 --> 00:21:06,090
you're right it's a lot of nothing

481
00:21:10,750 --> 00:21:09,120
before the excitement that's pretty

482
00:21:12,860 --> 00:21:10,760
early

483
00:21:15,290 --> 00:21:12,870
the excitement certainly thinks that

484
00:21:17,020 --> 00:21:15,300
one's good but you know it's every it's

485
00:21:19,750 --> 00:21:17,030
all good things you have to wait

486
00:21:23,330 --> 00:21:19,760
unfortunately Scott we're not seeing

487
00:21:23,990 --> 00:21:23,340
your screen yeah I can see it you can oh

488
00:21:26,450 --> 00:21:24,000

I can't

489
00:21:36,080 --> 00:21:26,460
wow we're okay well you tuned me not

490
00:21:38,900 --> 00:21:36,090
that much Carol if Kepler were in

491
00:21:40,970 --> 00:21:38,910
neutrino telescope so the neutrinos

492
00:21:43,010 --> 00:21:40,980
actually come out of the star very very

493
00:21:44,990 --> 00:21:43,020
easily there's not they don't interact

494
00:21:47,780 --> 00:21:45,000
with that with the gas and the envelope

495
00:21:50,030 --> 00:21:47,790
if we were to see this in neutrinos we

496
00:21:52,970 --> 00:21:50,040
would have seen a flash of neutrinos a

497
00:21:55,730 --> 00:21:52,980
day before we see the flash of the light

498
00:21:59,750 --> 00:21:55,740
so in in terms of precursor we're just

499
00:22:02,000 --> 00:21:59,760
on the right the right particles in

500
00:22:05,330 --> 00:22:02,010
photons instead of in nutrients yeah

501
00:22:07,220 --> 00:22:05,340
very difficult to see we pointed out

502
00:22:09,050 --> 00:22:07,230
there weakly interacting with us and so

503
00:22:10,460 --> 00:22:09,060
they go right straight through most

504
00:22:11,930 --> 00:22:10,470
things and they don't set off our

505
00:22:13,879 --> 00:22:11,940
detectors very well so

506
00:22:15,619 --> 00:22:13,889
that's hard they're hard to see but this

507
00:22:17,149 --> 00:22:15,629
is an explosion then even though it

508
00:22:19,600 --> 00:22:17,159
looks like an expansion of the outer

509
00:22:23,269 --> 00:22:19,610
atmosphere this is an explosion a

510
00:22:25,100 --> 00:22:23,279
supernova yes yes this is the the early

511
00:22:28,129 --> 00:22:25,110
moments when we first see it reach the

512
00:22:31,070 --> 00:22:28,139
surface of the star and it's two phases

513
00:22:33,499 --> 00:22:31,080

once the there's a shock inside which is

514
00:22:35,749 --> 00:22:33,509
a supernova as well and then we see it

515
00:22:38,539 --> 00:22:35,759
reaching the surface here and then the

516
00:22:42,919 --> 00:22:38,549
flash of the shock breakout and and the

517
00:22:45,440 --> 00:22:42,929
expanding envelope which which is the

518
00:22:48,889 --> 00:22:45,450
supernova itself okay

519
00:22:51,200 --> 00:22:48,899
well the this is the first time that

520
00:22:55,369 --> 00:22:51,210
this that this bow shock or this would

521
00:22:57,799 --> 00:22:55,379
have the shock wave has been seen or has

522
00:22:59,659 --> 00:22:57,809
been actually observed but this isn't a

523
00:23:01,279 --> 00:22:59,669
surprise right you guys knew this

524
00:23:04,430 --> 00:23:01,289
something like this would already happen

525
00:23:06,200 --> 00:23:04,440
correct or ISM just because it hadn't

526
00:23:07,999 --> 00:23:06,210
been observed as a mean you didn't know

527
00:23:09,560 --> 00:23:08,009
this something like this was there so

528
00:23:12,230 --> 00:23:09,570
this is the first time we've seen it at

529
00:23:16,970 --> 00:23:12,240
optical wavelengths it's actually been

530
00:23:19,789 --> 00:23:16,980
seen in in the ultraviolet in in in a

531
00:23:22,310 --> 00:23:19,799
few supernovae oh yeah

532
00:23:24,110 --> 00:23:22,320
that's not supergiant's not red

533
00:23:26,779 --> 00:23:24,120
supergiant's but in core collapse

534
00:23:29,299 --> 00:23:26,789
supernova there have been ultra violent

535
00:23:30,980 --> 00:23:29,309
officers okay great all right and most

536
00:23:32,299 --> 00:23:30,990
of those were lucky for in fact the

537
00:23:33,980 --> 00:23:32,309
first one was they were looking at

538
00:23:35,389 --> 00:23:33,990

another supernova and the supernova just

539
00:23:38,149 --> 00:23:35,399
happened to go off at the exact same

540
00:23:40,190 --> 00:23:38,159
moment so there was some evidence here

541
00:23:42,649 --> 00:23:40,200
and we wanted to kind of systematically

542
00:23:44,060 --> 00:23:42,659
you know on purpose search for it and

543
00:23:45,169 --> 00:23:44,070
look for it and I think when the

544
00:23:47,600 --> 00:23:45,179
interesting thing that's already come

545
00:23:49,759 --> 00:23:47,610
out as we saw the two soup exploding

546
00:23:52,999 --> 00:23:49,769
stars but we only saw the shockwave in

547
00:23:54,619 --> 00:23:53,009
one so already right there and looking

548
00:23:56,299 --> 00:23:54,629
at in a consistent way we know it's real

549
00:23:58,430 --> 00:23:56,309
but we only saw it and one is now was

550
00:23:59,690 --> 00:23:58,440
that because you didn't see it from the

551
00:24:01,519 --> 00:23:59,700
beginning or did you see it all

552
00:24:03,649 --> 00:24:01,529
completely through from the beginning uh

553
00:24:06,139 --> 00:24:03,659
why you said was a whole lot of nothing

554
00:24:07,879 --> 00:24:06,149
and then it got exciting real fast it or

555
00:24:08,899 --> 00:24:07,889
did you catch it at a different part of

556
00:24:11,480 --> 00:24:08,909
the light curve or did you see the

557
00:24:14,779 --> 00:24:11,490
entire thing and the one people for both

558
00:24:17,419 --> 00:24:14,789
we saw it the whole time we solo we we

559
00:24:19,789 --> 00:24:17,429
think with one there might be some some

560
00:24:21,529 --> 00:24:19,799
dusts or some other environmental

561
00:24:24,350 --> 00:24:21,539
circumstances that is preventing us from

562
00:24:25,820 --> 00:24:24,360
actually seeing that shockwave actually

563
00:24:27,230 --> 00:24:25,830

kind of reach it reach

564
00:24:30,110 --> 00:24:27,240
full brightness that's kind of being

565
00:24:32,360 --> 00:24:30,120
masked a little bit that that's our idea

566
00:24:34,490 --> 00:24:32,370
anyway but we saw the very early stages

567
00:24:37,039 --> 00:24:34,500
we saw really explode we just didn't see

568
00:24:38,389 --> 00:24:37,049
that quick shockwave so already it's

569
00:24:39,980 --> 00:24:38,399
telling us that there there is some

570
00:24:43,430 --> 00:24:39,990
interesting physics that goes on early

571
00:24:45,620 --> 00:24:43,440
times even more so than we kind of

572
00:24:48,350 --> 00:24:45,630
thought okay well these are being

573
00:24:49,789 --> 00:24:48,360
classified as type 2 supernova and you

574
00:24:51,769 --> 00:24:49,799
already mentioned that you that using

575
00:24:54,230 --> 00:24:51,779
Kepler data you found some type 1 A's

576
00:24:56,630 --> 00:24:54,240
tell us a little bit about what type 2

577
00:24:58,340 --> 00:24:56,640
are and how are they different from some

578
00:24:59,990 --> 00:24:58,350
of the other types of super also heard

579
00:25:04,370 --> 00:25:00,000
you say core-collapse is that is that

580
00:25:05,629 --> 00:25:04,380
synonymous so I tell my students all the

581
00:25:09,350 --> 00:25:05,639
time this is a kind of a complicated

582
00:25:11,960 --> 00:25:09,360
thing where astronomers have classified

583
00:25:14,690 --> 00:25:11,970
things based on their observations on on

584
00:25:18,110 --> 00:25:14,700
the spectra of of supernovae and it

585
00:25:20,990 --> 00:25:18,120
doesn't necessarily correlate match up

586
00:25:24,139 --> 00:25:21,000
one-to-one with what the models are for

587
00:25:26,659 --> 00:25:24,149
what we think is going on so a type 2

588
00:25:30,200 --> 00:25:26,669

supernova is just a supernova that shows

589
00:25:31,820 --> 00:25:30,210
hydrogen in its spectrum and a type 1

590
00:25:34,490 --> 00:25:31,830
supernova is one that doesn't show

591
00:25:39,830 --> 00:25:34,500
hydrogen in the spectra this goes way

592
00:25:42,139 --> 00:25:39,840
back to Ricky and bada and 100-inch

593
00:25:44,629 --> 00:25:42,149
telescope and their their first specter

594
00:25:48,409 --> 00:25:44,639
of of these things they realize there

595
00:25:52,070 --> 00:25:48,419
were two basic observational classes and

596
00:25:55,279 --> 00:25:52,080
and it turns out that type 1 supernova

597
00:25:57,740 --> 00:25:55,289
type 1 B and type 1 C supernovae are

598
00:26:01,789 --> 00:25:57,750
more related to type 2 and they are -

599
00:26:03,440 --> 00:26:01,799
the type 1 earth I sat down with Massimo

600
00:26:04,610 --> 00:26:03,450
C of LA one time in his office and he

601
00:26:06,080 --> 00:26:04,620
was trying to explain to me the

602
00:26:09,139 --> 00:26:06,090
different classifications of stars

603
00:26:18,200 --> 00:26:09,149
population to population 3 and all a

604
00:26:20,299 --> 00:26:18,210
makes this sounds like yeah this this

605
00:26:24,889 --> 00:26:20,309
just bolsters this statement that I say

606
00:26:30,980 --> 00:26:24,899
all the time astronomers just say stuff

607
00:26:33,090 --> 00:26:30,990
when they see it get in the way of a

608
00:26:39,930 --> 00:26:33,100
good transportation system

609
00:26:42,629 --> 00:26:39,940
know what that looks like what does that

610
00:26:47,129 --> 00:26:42,639
really mean astrophysically well nothing

611
00:26:50,490 --> 00:26:47,139
like dark matter but it comes out of

612
00:26:52,560 --> 00:26:50,500
your mouth and then it's sort of

613
00:26:54,180 --> 00:26:52,570

scientific Tourette's where you just

614
00:26:58,019 --> 00:26:54,190
blurt out little things they've been

615
00:27:00,299 --> 00:26:58,029
they somehow absolutely it's yeah you I

616
00:27:02,249 --> 00:27:00,309
know when I was excited doing my

617
00:27:04,620 --> 00:27:02,259
research and everybody else you just you

618
00:27:06,690 --> 00:27:04,630
turn into this child that gets so

619
00:27:08,759 --> 00:27:06,700
excited about anything come they're just

620
00:27:11,100 --> 00:27:08,769
words of nonsense come out and sometimes

621
00:27:13,470 --> 00:27:11,110
you get way too attached to one little

622
00:27:16,769 --> 00:27:13,480
thing even if it messes with everybody

623
00:27:18,269 --> 00:27:16,779
else's way of looking at the universe so

624
00:27:28,560 --> 00:27:18,279
I didn't come on this show to be

625
00:27:30,570 --> 00:27:28,570
ridiculed okay you didn't get that memo

626
00:27:37,610 --> 00:27:30,580
Peter that's it it over one memo you're

627
00:27:45,330 --> 00:27:42,509
you'll never be back you're right

628
00:27:47,639 --> 00:27:45,340
this is a historical thing we start out

629
00:27:49,710 --> 00:27:47,649
with no knowledge at all you start doing

630
00:27:52,350 --> 00:27:49,720
the observation than the classifications

631
00:27:55,080 --> 00:27:52,360
and only later do we find out that the

632
00:27:56,159 --> 00:27:55,090
the physics is is you know different

633
00:27:58,799 --> 00:27:56,169
than what we were doing with the

634
00:28:01,259 --> 00:27:58,809
classifications so in a classification

635
00:28:04,590 --> 00:28:01,269
in a in a physic sense we have basically

636
00:28:07,529 --> 00:28:04,600
two kinds of explosions we have massive

637
00:28:09,960 --> 00:28:07,539
stars that run out of energy in their

638
00:28:11,909 --> 00:28:09,970

center the core collapses down to a

639
00:28:14,279 --> 00:28:11,919
neutron stars maybe even a black hole

640
00:28:16,789 --> 00:28:14,289
sometimes and that we call a core

641
00:28:19,350 --> 00:28:16,799
collapse supernova and there are several

642
00:28:22,039 --> 00:28:19,360
spectroscopic types that correspond to

643
00:28:26,129 --> 00:28:22,049
that and the other side is a white dwarf

644
00:28:28,799 --> 00:28:26,139
that has a thermonuclear runaway runaway

645
00:28:32,700 --> 00:28:28,809
fusion in its center it's consumed in

646
00:28:35,220 --> 00:28:32,710
this in this fusion it it makes a type

647
00:28:36,509 --> 00:28:35,230
1a supernova and those are thus the

648
00:28:38,700 --> 00:28:36,519
basic two types

649
00:28:40,950 --> 00:28:38,710
okay well earlier I was asking you guys

650
00:28:42,330 --> 00:28:40,960
about the difference between the you

651
00:28:44,279 --> 00:28:42,340
know we tell my red giants and what our

652
00:28:44,880 --> 00:28:44,289
Sun is going to do and red supergiant

653
00:28:47,820 --> 00:28:44,890
and how the

654
00:28:48,840 --> 00:28:47,830
is different I've been taught and I'm

655
00:28:50,580 --> 00:28:48,850
thinking a lot of us have been taught

656
00:28:53,640 --> 00:28:50,590
that our Sun when it dies is gonna leave

657
00:28:56,280 --> 00:28:53,650
behind a white dwarf at its core and

658
00:28:58,760 --> 00:28:56,290
what about these type 2 supernovas what

659
00:29:01,110 --> 00:28:58,770
kind of remnant do they leave behind

660
00:29:03,570 --> 00:29:01,120
Brad you want to take that one yes and

661
00:29:05,820 --> 00:29:03,580
say so muslim' leave a neutron star and

662
00:29:07,710 --> 00:29:05,830
it's the the whole process is quite

663
00:29:09,780 --> 00:29:07,720

interesting right and we've known for a

664
00:29:11,400 --> 00:29:09,790
long time and believe you know we were

665
00:29:13,200 --> 00:29:11,410
talking about physics getting in the way

666
00:29:14,550 --> 00:29:13,210
well we've always had the physical

667
00:29:16,410 --> 00:29:14,560
understanding we just haven't had fully

668
00:29:18,120 --> 00:29:16,420
the observational understanding and I

669
00:29:19,800 --> 00:29:18,130
think a good way I always like to

670
00:29:22,020 --> 00:29:19,810
explain this is if you take dirt and

671
00:29:24,300 --> 00:29:22,030
compress it in your hand at some point

672
00:29:26,580 --> 00:29:24,310
you can't compress it enough and then

673
00:29:28,670 --> 00:29:26,590
your hands kind of bounce off and that's

674
00:29:31,920 --> 00:29:28,680
the process what happens it stars

675
00:29:33,690 --> 00:29:31,930
collapsed it and compress that material

676
00:29:35,400 --> 00:29:33,700
and then your hands have bounced off in

677
00:29:38,040 --> 00:29:35,410
that initial bouncing off is this shock

678
00:29:40,320 --> 00:29:38,050
wave so the majority of stars we think

679
00:29:41,790 --> 00:29:40,330
about are these core clip so Betelgeuse

680
00:29:44,340 --> 00:29:41,800
is going to be a core collapse star for

681
00:29:47,160 --> 00:29:44,350
instance so you know Betelgeuse and

682
00:29:48,960 --> 00:29:47,170
Orion is due to blow up any day as I say

683
00:29:52,350 --> 00:29:48,970
and in astronomy terms as you know that

684
00:29:56,040 --> 00:29:52,360
means like 20,000 years any day now

685
00:29:57,720 --> 00:29:56,050
but it is those are the general stars

686
00:30:01,350 --> 00:29:57,730
that were thought of and so they leave

687
00:30:03,780 --> 00:30:01,360
behind a neutron star we think even more

688
00:30:06,390 --> 00:30:03,790

larger supergiant stars can leave behind

689
00:30:08,070 --> 00:30:06,400
black holes though that process have

690
00:30:09,750 --> 00:30:08,080
never been saved you've never actually

691
00:30:12,150 --> 00:30:09,760
seen the neutron star and there's not

692
00:30:13,320 --> 00:30:12,160
necessarily a really hard boundary

693
00:30:14,760 --> 00:30:13,330
between when you get a neutron star

694
00:30:16,320 --> 00:30:14,770
versus a black hole core I mean it's

695
00:30:18,300 --> 00:30:16,330
kind of a range of their conditions

696
00:30:19,860 --> 00:30:18,310
exactly we think there's a range and we

697
00:30:22,200 --> 00:30:19,870
would like to see this direct process

698
00:30:25,170 --> 00:30:22,210
happening and so we infer that there's a

699
00:30:27,840 --> 00:30:25,180
neutron star but we obviously didn't see

700
00:30:30,300 --> 00:30:27,850
the neutron stars so this shock breakout

701
00:30:31,770 --> 00:30:30,310
that we were talking about today I love

702
00:30:33,390 --> 00:30:31,780
what you just said it was you know this

703
00:30:34,920 --> 00:30:33,400
idea that you're pushing and pushing on

704
00:30:37,290 --> 00:30:34,930
the core and boom you're bounced back

705
00:30:39,420 --> 00:30:37,300
that is what we're seeing right it's

706
00:30:41,850 --> 00:30:39,430
that sort of push back from the collapse

707
00:30:44,010 --> 00:30:41,860
of this core of this core and a neutron

708
00:30:47,490 --> 00:30:44,020
star is extremely dense give us an idea

709
00:30:49,500 --> 00:30:47,500
just how dense that is so I think if you

710
00:30:54,330 --> 00:30:49,510
were to take a spoonful of the Sun you

711
00:30:57,060 --> 00:30:54,340
get about five grams of material that

712
00:30:58,410 --> 00:30:57,070
tasty Sun now neutron starts and it's

713
00:30:59,850 --> 00:30:58,420

tasty

714
00:31:01,890 --> 00:30:59,860
but I think if you take a better

715
00:31:04,460 --> 00:31:01,900
neutrons a spoonful of a neutron star

716
00:31:07,620 --> 00:31:04,470
you get about a hundred thousand grams

717
00:31:10,830 --> 00:31:07,630
so neutron stars are much more dense now

718
00:31:13,440 --> 00:31:10,840
it's not as dense the black coal but a

719
00:31:16,980 --> 00:31:13,450
you know the the neutron star that would

720
00:31:18,630 --> 00:31:16,990
have been created in this this explosion

721
00:31:21,120 --> 00:31:18,640
that we saw would have been smaller than

722
00:31:23,490 --> 00:31:21,130
the earth physical size so the radius

723
00:31:25,620 --> 00:31:23,500
would have been smaller than the earth

724
00:31:28,230 --> 00:31:25,630
but it would have been heavier than the

725
00:31:30,030 --> 00:31:28,240
Sun so these are really dense really

726
00:31:32,220 --> 00:31:30,040
heavy things okay well let me get to

727
00:31:34,050 --> 00:31:32,230
Astro girl one usa's question which is

728
00:31:36,810 --> 00:31:34,060
and welcome back by the way it's good to

729
00:31:38,720 --> 00:31:36,820
see you back so she's asking a very

730
00:31:41,640 --> 00:31:38,730
relevant question at this point do all

731
00:31:43,500 --> 00:31:41,650
supernovae have shockwaves or just type

732
00:31:45,210 --> 00:31:43,510
two that bounce back you're talking

733
00:31:47,130 --> 00:31:45,220
about is that only is that a signature

734
00:31:50,700 --> 00:31:47,140
of type two or will we see that

735
00:31:54,630 --> 00:31:50,710
somewhere else another life supernova so

736
00:31:56,850 --> 00:31:54,640
yeah I think it was it's true that all

737
00:31:59,250 --> 00:31:56,860
core-collapse supernovae so these are

738
00:32:02,750 --> 00:31:59,260

these are things where that neutron star

739
00:32:06,360 --> 00:32:02,760
is is formed and it has an outer layer

740
00:32:08,670 --> 00:32:06,370
envelope to it that they're the shock

741
00:32:11,970 --> 00:32:08,680
the breakout will occur in all of these

742
00:32:14,040 --> 00:32:11,980
different brightnesses so it turns out

743
00:32:16,950 --> 00:32:14,050
that these red supergiant's which are

744
00:32:18,960 --> 00:32:16,960
are so large give you brighter shock

745
00:32:21,780 --> 00:32:18,970
breakouts than something more compact

746
00:32:24,600 --> 00:32:21,790
where the hydrogen envelope has been

747
00:32:26,760 --> 00:32:24,610
lost or something like that so you'll

748
00:32:28,200 --> 00:32:26,770
still get a shock breakout but it's not

749
00:32:32,940 --> 00:32:28,210
going to be as bright as you see in

750
00:32:34,650 --> 00:32:32,950
these very large red supergiant stars no

751
00:32:35,730 --> 00:32:34,660
so these are fascinating okay well I'm

752
00:32:38,190 --> 00:32:35,740
gonna go back I want to go back to a

753
00:32:39,990 --> 00:32:38,200
Twitter comment that Joel Edward 86

754
00:32:42,690 --> 00:32:40,000
asked and this is sort of goes back to

755
00:32:43,980 --> 00:32:42,700
what you were just commenting on Brad so

756
00:32:45,360 --> 00:32:43,990
I'd like you to follow up with this you

757
00:32:48,150 --> 00:32:45,370
mentioned Betelgeuse so I'm gonna go

758
00:32:50,520 --> 00:32:48,160
ahead let's do it is Betelgeuse near two

759
00:32:52,560 --> 00:32:50,530
supernova and you said any day now and

760
00:32:54,420 --> 00:32:52,570
if so what would that look like from the

761
00:32:57,090 --> 00:32:54,430
earth tell us about what that might look

762
00:33:01,050 --> 00:32:57,100
like it'd be awesome firstly I made a

763
00:33:05,040 --> 00:33:01,060

you know you're just blowing me away

764
00:33:07,850 --> 00:33:05,050
okay it's a I'm really waiting for

765
00:33:11,950 --> 00:33:07,860
Betelgeuse to blow up I call it employer

766
00:33:15,010 --> 00:33:11,960
you know it's Betelgeuse

767
00:33:17,710 --> 00:33:15,020
we'll be very bright you know it's not

768
00:33:19,090 --> 00:33:17,720
gonna be like a new Sun I mean I think

769
00:33:20,799 --> 00:33:19,100
some people think that it will just be

770
00:33:23,620 --> 00:33:20,809
this you know there's very bright thing

771
00:33:25,780 --> 00:33:23,630
firstly we'll see the neutrinos first so

772
00:33:27,400 --> 00:33:25,790
the those high-energy particles that

773
00:33:29,590 --> 00:33:27,410
we're talking about earlier leaving the

774
00:33:30,850 --> 00:33:29,600
the inside of the star we should be able

775
00:33:32,980 --> 00:33:30,860
to see them with our ground-based

776
00:33:35,799 --> 00:33:32,990
detectors and kind of know about it a

777
00:33:37,840 --> 00:33:35,809
few minutes ahead of time and then we'll

778
00:33:40,690 --> 00:33:37,850
see the light I think their general

779
00:33:43,240 --> 00:33:40,700
consensus is when Betelgeuse blows up it

780
00:33:44,799 --> 00:33:43,250
will be bright for months visible to the

781
00:33:47,410 --> 00:33:44,809
naked eye

782
00:33:48,850 --> 00:33:47,420
we should probably you know at peak you

783
00:33:51,430 --> 00:33:48,860
know probably brighter than the full

784
00:33:54,250 --> 00:33:51,440
moon that's what we may be able to see

785
00:33:56,110 --> 00:33:54,260
it then we'd be able to potentially I

786
00:33:58,960 --> 00:33:56,120
mean there is you know debate about

787
00:34:00,940 --> 00:33:58,970
exactly how bright it is it's we there's

788
00:34:03,730 --> 00:34:00,950

very few cases where we've seen a very

789
00:34:08,710 --> 00:34:03,740
studied evolve star and then see it blow

790
00:34:11,200 --> 00:34:08,720
up but it will be a good example 1987a

791
00:34:12,820 --> 00:34:11,210
the supernova we call 1987a which

792
00:34:15,760 --> 00:34:12,830
occurred in our neighbor galaxy the

793
00:34:18,010 --> 00:34:15,770
Large Magellanic Cloud now this is

794
00:34:19,540 --> 00:34:18,020
thousands of light years are tens of

795
00:34:21,639 --> 00:34:19,550
thousands of light years away but when

796
00:34:23,169 --> 00:34:21,649
it blew up it was so bright our

797
00:34:25,810 --> 00:34:23,179
professional telescopes couldn't

798
00:34:27,790 --> 00:34:25,820
actually even use it because it was so

799
00:34:29,139 --> 00:34:27,800
bright it saturated our measurement so

800
00:34:32,740 --> 00:34:29,149
you can imagine something that's in our

801
00:34:35,139 --> 00:34:32,750
backyard how bright scaling wise that

802
00:34:36,460 --> 00:34:35,149
would be so whenever it blows up it

803
00:34:37,780 --> 00:34:36,470
won't harm the earth you know we're not

804
00:34:39,399 --> 00:34:37,790
we're not in trouble we're not in danger

805
00:34:43,750 --> 00:34:39,409
we don't have to call Bruce Willis or

806
00:34:46,810 --> 00:34:43,760
anything like that but it will be a Cool

807
00:34:48,970 --> 00:34:46,820
J Willis at it but it'll be a great show

808
00:34:51,040 --> 00:34:48,980
nonetheless yeah we're gonna have them

809
00:34:53,139 --> 00:34:51,050
go drill the supernova just just think

810
00:35:03,160 --> 00:34:53,149
exactly Oh Smith playing in the

811
00:35:05,380 --> 00:35:03,170
background I'm with you well the the so

812
00:35:06,790 --> 00:35:05,390
they have what about the the density of

813
00:35:09,070 --> 00:35:06,800

these star oh I know what I want to get

814
00:35:11,020 --> 00:35:09,080
to so I'm gonna go back to the neutrino

815
00:35:13,750 --> 00:35:11,030
comment you made earlier we have

816
00:35:15,070 --> 00:35:13,760
detectors you the ground-based detectors

817
00:35:16,660 --> 00:35:15,080
are deep underground I think some of

818
00:35:18,550 --> 00:35:16,670
them are in Japan some of our might I

819
00:35:20,890 --> 00:35:18,560
forget where they all are one of them is

820
00:35:23,260 --> 00:35:20,900
called super k kamiokande or something

821
00:35:25,540 --> 00:35:23,270
like that those are those all those are

822
00:35:27,510 --> 00:35:25,550
always on right and they will

823
00:35:29,800 --> 00:35:27,520
TEKT an influx of neutrinos do you guys

824
00:35:31,150 --> 00:35:29,810
rely on that as any kind of early

825
00:35:32,680 --> 00:35:31,160
warning system at all do they let you

826
00:35:35,680 --> 00:35:32,690
guys know when they're when they see a

827
00:35:37,440 --> 00:35:35,690
sudden influx of neutrinos it's it's

828
00:35:41,470 --> 00:35:37,450
funny that you say that but there is a

829
00:35:43,150 --> 00:35:41,480
network of neutrino detectors I think

830
00:35:48,250 --> 00:35:43,160
it's true they're awesome or something

831
00:35:52,570 --> 00:35:48,260
yeah supernova alert yeah yeah and and I

832
00:35:55,630 --> 00:35:52,580
I am signed up for it so if several of

833
00:35:59,110 --> 00:35:55,640
these neutrino detectors show a spike in

834
00:36:01,480 --> 00:35:59,120
rates they they will send out an

835
00:36:04,300 --> 00:36:01,490
automatic alert saying hey something is

836
00:36:06,790 --> 00:36:04,310
going on and and then it'll be up to us

837
00:36:09,490 --> 00:36:06,800
optical astronomers to go out and and

838
00:36:12,070 --> 00:36:09,500

look for a galactic supernova because

839
00:36:14,770 --> 00:36:12,080
they won't have the sensitivity beyond

840
00:36:17,620 --> 00:36:14,780
save a large and small Magellanic Clouds

841
00:36:20,410 --> 00:36:17,630
so I'm not even sure Andromeda they'll

842
00:36:23,710 --> 00:36:20,420
be able to detect very much but in our

843
00:36:26,470 --> 00:36:23,720
galaxy it should be a fairly clear spike

844
00:36:28,620 --> 00:36:26,480
of neutrinos these days the the neutrino

845
00:36:32,020 --> 00:36:28,630
detectors have gotten a lot better since

846
00:36:35,830 --> 00:36:32,030
1987 when I think it was 19 or 18

847
00:36:38,350 --> 00:36:35,840
neutrinos were detected from 1987a and

848
00:36:40,510 --> 00:36:38,360
the Large Magellanic Cloud so they're

849
00:36:42,810 --> 00:36:40,520
expecting thousands of neutrinos to be

850
00:36:45,430 --> 00:36:42,820
detected from a galactic supernova and

851
00:36:47,710 --> 00:36:45,440
it should be a pretty clear signal and

852
00:36:50,830 --> 00:36:47,720
then we can go start looking for it in

853
00:36:53,620 --> 00:36:50,840
the optical are they directional enough

854
00:36:55,480 --> 00:36:53,630
to give you a sense of where to look I

855
00:36:57,070 --> 00:36:55,490
mean I know that these they only you

856
00:36:59,710 --> 00:36:57,080
only have a few neutrinos to work with

857
00:37:01,870 --> 00:36:59,720
each time but if several throughout the

858
00:37:02,830 --> 00:37:01,880
globe were able to detect them can you

859
00:37:08,070 --> 00:37:02,840
kind of get a sense of where they're

860
00:37:14,380 --> 00:37:12,100
that any any couple of neutrinos will do

861
00:37:17,650 --> 00:37:14,390
it but the large number of neutrinos

862
00:37:20,680 --> 00:37:17,660
that say go to super-k you can get a

863
00:37:23,440 --> 00:37:20,690

directional signal from that the flash

864
00:37:25,300 --> 00:37:23,450
of strength off radiation points in the

865
00:37:27,250 --> 00:37:25,310
opposite direction general opposite

866
00:37:29,560 --> 00:37:27,260
direction of where the where the

867
00:37:32,170 --> 00:37:29,570
neutrino came from so we could probably

868
00:37:35,530 --> 00:37:32,180
narrow it down to maybe twenty or thirty

869
00:37:37,300 --> 00:37:35,540
degrees on the sky where the where the

870
00:37:39,550 --> 00:37:37,310
supernova is coming from and a core

871
00:37:41,650 --> 00:37:39,560
collapse supernovae generally comes from

872
00:37:43,720 --> 00:37:41,660
an extremely young population of stars

873
00:37:46,870 --> 00:37:43,730
so it will probably be constrained to

874
00:37:48,930 --> 00:37:46,880
the disk of our galaxy so we'll know

875
00:37:52,780 --> 00:37:48,940
pretty well from the neutrino flash

876
00:37:54,190 --> 00:37:52,790
where where doesn't don't look so wait a

877
00:37:56,620 --> 00:37:54,200
minute these two supernovas we're

878
00:37:58,450 --> 00:37:56,630
talking about today they are from

879
00:37:59,860 --> 00:37:58,460
galaxies pretty far away then we're

880
00:38:03,160 --> 00:37:59,870
talking billions of light-years away

881
00:38:04,810 --> 00:38:03,170
right so we would not necessarily where

882
00:38:06,600 --> 00:38:04,820
we probably wouldn't I don't think get

883
00:38:09,930 --> 00:38:06,610
any neutrinos from these would be

884
00:38:12,310 --> 00:38:09,940
absolutely not say they are very distant

885
00:38:15,550 --> 00:38:12,320
so like I was saying even even though

886
00:38:17,950 --> 00:38:15,560
our nearest galaxies Andromeda and

887
00:38:20,860 --> 00:38:17,960
beyond I don't think it's possible to

888
00:38:22,570 --> 00:38:20,870

get a together you to know that so

889
00:38:24,940 --> 00:38:22,580
neutrino detectors are very helpful for

890
00:38:26,470 --> 00:38:24,950
things happening within our galaxy I

891
00:38:28,030 --> 00:38:26,480
mean and I think that's kind of the

892
00:38:29,680 --> 00:38:28,040
impressive part when we go back to about

893
00:38:32,170 --> 00:38:29,690
these kepler observations we're seeing a

894
00:38:35,620 --> 00:38:32,180
shock wave from a neutron star that was

895
00:38:39,040 --> 00:38:35,630
created in the collection of a star 1.2

896
00:38:41,290 --> 00:38:39,050
billion light-years away and that's how

897
00:38:42,580 --> 00:38:41,300
sensitive Kepler is you can't do this

898
00:38:45,130 --> 00:38:42,590
from the ground you can't do this with

899
00:38:47,140 --> 00:38:45,140
other instruments and that is where the

900
00:38:49,870 --> 00:38:47,150
the strengths of Kepler has really

901
00:38:51,340 --> 00:38:49,880
allowed us to do these discoveries and I

902
00:38:52,690 --> 00:38:51,350
was so easy doing these hangouts to just

903
00:38:54,910 --> 00:38:52,700
be flippant about numbers like that oh

904
00:38:56,500 --> 00:38:54,920
yeah 1.2 1.2 million what's a couple

905
00:38:58,660 --> 00:38:56,510
million light-years between friends I

906
00:39:00,490 --> 00:38:58,670
don't get the problem here so oK we've

907
00:39:02,620 --> 00:39:00,500
got some more good questions here I want

908
00:39:05,800 --> 00:39:02,630
to get to some of them here what

909
00:39:07,690 --> 00:39:05,810
Christopher boy it must be Pettersen

910
00:39:09,010 --> 00:39:07,700
with all those T's so I an S is so I'm

911
00:39:11,020 --> 00:39:09,020
just gonna say it that way Christopher

912
00:39:14,890 --> 00:39:11,030
Patterson what is the density of these

913
00:39:17,230 --> 00:39:14,900

giant stars compared to the Sun do these

914
00:39:19,290 --> 00:39:17,240
giants just get bloated once the star

915
00:39:21,370 --> 00:39:19,300
mass or the mass starts to go up now

916
00:39:22,720 --> 00:39:21,380
that I'm kind of wondering you know I

917
00:39:25,330 --> 00:39:22,730
was kind of clarifying that a little bit

918
00:39:26,500 --> 00:39:25,340
earlier in the hangout how do these what

919
00:39:28,480 --> 00:39:26,510
is it what are the density of these

920
00:39:29,500 --> 00:39:28,490
stars and we you give the size in the

921
00:39:32,050 --> 00:39:29,510
press release but we don't talk about

922
00:39:33,370 --> 00:39:32,060
the mass so much how do these how do

923
00:39:36,310 --> 00:39:33,380
they compare as far as the mass of the

924
00:39:38,560 --> 00:39:36,320
Sun and the density right so our

925
00:39:40,900 --> 00:39:38,570
observations actually are pretty good at

926
00:39:43,150 --> 00:39:40,910
constraining the size of the star when

927
00:39:45,340 --> 00:39:43,160
it exploded but not very good at

928
00:39:48,400 --> 00:39:45,350
constraining the mass so we rely on

929
00:39:50,650 --> 00:39:48,410
models for that and in general the core

930
00:39:53,110 --> 00:39:50,660
collapse supernovae will only happen for

931
00:39:56,230 --> 00:39:53,120
stars that are about 8 solar masses

932
00:39:58,270 --> 00:39:56,240
and and higher so start there it's got

933
00:39:59,950 --> 00:39:58,280
less than that right it's not less than

934
00:40:02,740 --> 00:39:59,960
that less than that you end up with

935
00:40:05,860 --> 00:40:02,750
white doors being formed stable white

936
00:40:09,190 --> 00:40:05,870
dwarves more than that you can get core

937
00:40:11,950 --> 00:40:09,200
collapse supernovae and and and so these

938
00:40:14,020 --> 00:40:11,960

stars are are typically because there

939
00:40:15,700 --> 00:40:14,030
are many more lower mass stars and high

940
00:40:19,960 --> 00:40:15,710
mass stars they're going to be typically

941
00:40:22,480 --> 00:40:19,970
10 to 15 solar masses in when they

942
00:40:28,840 --> 00:40:22,490
finally evolve to the point of exploding

943
00:40:31,540 --> 00:40:28,850
now yes it's not bad you know but still

944
00:40:33,940 --> 00:40:31,550
corresponds to a 300 times and a 500

945
00:40:36,100 --> 00:40:33,950
times a respective Li of the size of our

946
00:40:39,430 --> 00:40:36,110
own Sun so it's a pretty big star for

947
00:40:41,980 --> 00:40:39,440
sure it's a big star not that much more

948
00:40:43,750 --> 00:40:41,990
mass so in fact as Brad was saying you

949
00:40:46,900 --> 00:40:43,760
take a little bit of the Sun and you get

950
00:40:49,570 --> 00:40:46,910
like 3 3 grams because the kind of the

951
00:40:51,790 --> 00:40:49,580
average density of the Sun take it as a

952
00:40:56,080 --> 00:40:51,800
whole is on the order of the density of

953
00:40:58,750 --> 00:40:56,090
water but these stars are a few times 15

954
00:41:00,670 --> 00:40:58,760
times more massive than the Sun but you

955
00:41:03,010 --> 00:41:00,680
know a thousand times bigger so they're

956
00:41:08,140 --> 00:41:03,020
their average density is very very low

957
00:41:10,420 --> 00:41:08,150
it's you know it's air at the very edges

958
00:41:13,150 --> 00:41:10,430
a good question question for thank you

959
00:41:14,500 --> 00:41:13,160
so a stronger one USA I'm gonna ask this

960
00:41:16,180 --> 00:41:14,510
question even though I've read it

961
00:41:18,160 --> 00:41:16,190
several times I may ask you to clarify

962
00:41:19,090 --> 00:41:18,170
it because I'm not sure I understand

963
00:41:21,010 --> 00:41:19,100

what you mean I'm gonna say what I think

964
00:41:21,670 --> 00:41:21,020
you mean and if I'm wrong please comment

965
00:41:23,500 --> 00:41:21,680
on it

966
00:41:25,150 --> 00:41:23,510
she's asking do we have a way of

967
00:41:27,490 --> 00:41:25,160
including dark energy in our

968
00:41:29,290 --> 00:41:27,500
calculations of how far away a type 1a

969
00:41:31,390 --> 00:41:29,300
supernova is now type 1a are these

970
00:41:33,040 --> 00:41:31,400
standard candles where that they have we

971
00:41:34,300 --> 00:41:33,050
know their intrinsic brightness and by

972
00:41:36,490 --> 00:41:34,310
knowing their intrinsic brightness we

973
00:41:38,320 --> 00:41:36,500
can estimate their their distance based

974
00:41:40,360 --> 00:41:38,330
on that we can calculate their distance

975
00:41:43,750 --> 00:41:40,370
I think what she's asking is because the

976
00:41:45,430 --> 00:41:43,760
dark energy expanding of the universe

977
00:41:47,650 --> 00:41:45,440
during the time of the explosion perhaps

978
00:41:49,870 --> 00:41:47,660
do we have a way of compensating for the

979
00:41:52,630 --> 00:41:49,880
effects of dark energy I hope I asked

980
00:41:53,710 --> 00:41:52,640
that right astro girl 1 USA it doesn't

981
00:41:56,920 --> 00:41:53,720
make sense what I've asked you just now

982
00:41:59,950 --> 00:41:56,930
Peter and Brad well not not completely

983
00:42:02,830 --> 00:41:59,960
to me I you know I I think when we're

984
00:42:04,450 --> 00:42:02,840
talking about distant supernovae the

985
00:42:06,550 --> 00:42:04,460
light has to travel through the universe

986
00:42:09,160 --> 00:42:06,560
and then we need

987
00:42:10,450 --> 00:42:09,170
take into account dark energy to account

988
00:42:13,390 --> 00:42:10,460

for the exciting that's what she's

989
00:42:16,570 --> 00:42:13,400
asking so there would be an expansion of

990
00:42:19,420 --> 00:42:16,580
the universe with moves being annexed

991
00:42:20,740 --> 00:42:19,430
so I got that right okay so do we do

992
00:42:22,210 --> 00:42:20,750
that I mean I don't know that we know

993
00:42:23,500 --> 00:42:22,220
and I guess the Hubble constant comes

994
00:42:25,420 --> 00:42:23,510
into play that's this number that gives

995
00:42:28,510 --> 00:42:25,430
us the rate of expansion any given time

996
00:42:31,090 --> 00:42:28,520
in the universe do we apply these when

997
00:42:34,540 --> 00:42:31,100
you look at these 1.2 billion light year

998
00:42:38,110 --> 00:42:34,550
galaxies so 1.2 billion laser sounds

999
00:42:40,210 --> 00:42:38,120
like a very very far away galaxy really

1000
00:42:44,470 --> 00:42:40,220
girly when it comes to the cosmological

1001
00:42:47,230 --> 00:42:44,480
expansion and that the effects of dark

1002
00:42:50,530 --> 00:42:47,240
energy it's it's not that important so

1003
00:42:53,200 --> 00:42:50,540
yeah we're talking about is not an it's

1004
00:42:55,960 --> 00:42:53,210
not ideal right so dark energy was

1005
00:43:00,040 --> 00:42:55,970
discovered using supernovae at distances

1006
00:43:02,260 --> 00:43:00,050
of like five billion light years so a

1007
00:43:05,530 --> 00:43:02,270
billion light years is just a little too

1008
00:43:08,440 --> 00:43:05,540
close for for it to be an important a

1009
00:43:09,940 --> 00:43:08,450
part of the of the light that's a good

1010
00:43:11,800 --> 00:43:09,950
point by comparison the observable

1011
00:43:14,950 --> 00:43:11,810
universe is has a radius of forty

1012
00:43:16,600 --> 00:43:14,960
billion light years so so yeah I guess

1013
00:43:18,970 --> 00:43:16,610

you're right on that scale that's pretty

1014
00:43:21,160 --> 00:43:18,980
small dynamic universe on YouTube is

1015
00:43:23,230 --> 00:43:21,170
asking do they know why some stars about

1016
00:43:25,990 --> 00:43:23,240
the mass of the Sun puff the outer

1017
00:43:28,090 --> 00:43:26,000
layers like in the cat's eye nebula or

1018
00:43:31,630 --> 00:43:28,100
these the ring nebula which is another

1019
00:43:35,230 --> 00:43:31,640
famous one note from Scott better read

1020
00:43:36,970 --> 00:43:35,240
that one that's me yeah your head I was

1021
00:43:38,920 --> 00:43:36,980
just talking about since we just talked

1022
00:43:41,020 --> 00:43:38,930
about going right to white dwarf maybe

1023
00:43:42,780 --> 00:43:41,030
include the part where planetary nebula

1024
00:43:45,130 --> 00:43:42,790
is something it could happen with ours

1025
00:43:49,060 --> 00:43:45,140
okay so yeah so why don't we talk about

1026
00:43:51,130 --> 00:43:49,070
that why do some stars like our Sun just

1027
00:43:53,500 --> 00:43:51,140
shed its outer layer of gas and

1028
00:43:56,670 --> 00:43:53,510
essentially by comparison to a pretty

1029
00:44:01,870 --> 00:43:56,680
boring thing and other stars do this

1030
00:44:03,760 --> 00:44:01,880
Brad you got up early for this one train

1031
00:44:12,120 --> 00:44:03,770
your brain see this onion I don't know

1032
00:44:12,130 --> 00:44:17,170
the Sun is dead to me

1033
00:44:28,550 --> 00:44:20,780
Tony can't see the Sun either oh it's

1034
00:44:36,290 --> 00:44:28,560
it's just this now I just Scott I they

1035
00:44:38,300 --> 00:44:36,300
rarely see the Sun as it is okay I think

1036
00:44:40,520 --> 00:44:38,310
that's a good question it is all part of

1037
00:44:43,010 --> 00:44:40,530
this this uding using the fuel that as

1038
00:44:45,080 --> 00:44:43,020

you use the the first layers of feel the

1039
00:44:46,790 --> 00:44:45,090
hydrogen feel those layers get

1040
00:44:49,280 --> 00:44:46,800
eventually puffed out and then you go

1041
00:44:51,530 --> 00:44:49,290
through the heavier elements to helium

1042
00:44:52,520 --> 00:44:51,540
and then you do some carbon and oxygen

1043
00:44:54,800 --> 00:44:52,530
and oxygen

1044
00:44:56,210 --> 00:44:54,810
all of those slowly get puffed out now

1045
00:44:58,820 --> 00:44:56,220
in a smaller star like our Sun

1046
00:45:01,670 --> 00:44:58,830
eventually those things have just puffed

1047
00:45:04,940 --> 00:45:01,680
out over time and you're left with that

1048
00:45:08,150 --> 00:45:04,950
iron core that white dwarf which brought

1049
00:45:10,580 --> 00:45:08,160
it burns a little bit bright but burns

1050
00:45:13,790 --> 00:45:10,590
inside the star creating these not very

1051
00:45:15,860 --> 00:45:13,800
nice planetary nebulae whereas with

1052
00:45:19,580 --> 00:45:15,870
these these heavier stars that blow off

1053
00:45:22,340 --> 00:45:19,590
if they were not to collapse in on

1054
00:45:26,420 --> 00:45:22,350
themselves you would get great nebulae

1055
00:45:28,400 --> 00:45:26,430
you would get huge balls of this gas of

1056
00:45:29,870 --> 00:45:28,410
the hydrogen expanding and the helium

1057
00:45:33,740 --> 00:45:29,880
and all these other gases you would get

1058
00:45:36,050 --> 00:45:33,750
massive nebulae that would be fantastic

1059
00:45:38,600 --> 00:45:36,060
but the process you know gravity

1060
00:45:39,620 --> 00:45:38,610
ultimately wins gravity is heartless it

1061
00:45:42,320 --> 00:45:39,630
always wins

1062
00:45:45,920 --> 00:45:42,330
and so these stars collapse and so

1063
00:45:48,680 --> 00:45:45,930

before it gets to that phase it blows up

1064
00:45:50,510 --> 00:45:48,690
so in theory you could get a large star

1065
00:45:52,820 --> 00:45:50,520
that creates a planetary nebulae but

1066
00:45:54,710 --> 00:45:52,830
it's just unlikely to create such a

1067
00:45:56,300 --> 00:45:54,720
large one without collapsing well what

1068
00:45:58,190 --> 00:45:56,310
you get instead is more like what the

1069
00:46:00,620 --> 00:45:58,200
Crab Nebula is right you get more of a

1070
00:46:02,780 --> 00:46:00,630
nebula that was created from our core

1071
00:46:04,400 --> 00:46:02,790
that's what will create a slightly

1072
00:46:06,410 --> 00:46:04,410
different I mean those those dad's gas

1073
00:46:08,510 --> 00:46:06,420
layers will expand and you know

1074
00:46:10,460 --> 00:46:08,520
eventually those form the new stars

1075
00:46:12,650 --> 00:46:10,470
right you know that's it is that process

1076
00:46:14,360 --> 00:46:12,660
this is this this whole process of going

1077
00:46:16,520 --> 00:46:14,370
on and I always like to stress the

1078
00:46:18,650 --> 00:46:16,530
universe is good at recycling right yeah

1079
00:46:18,650 --> 00:46:18,660
exactly

1080
00:46:24,410 --> 00:46:22,250
yes the trick yeah look at that if you

1081
00:46:27,710 --> 00:46:24,420
look at the Crab Nebula the velocities

1082
00:46:28,960 --> 00:46:27,720
of that are much much higher than in a

1083
00:46:32,950 --> 00:46:28,970
planetary nebula

1084
00:46:34,839 --> 00:46:32,960
the crabby above- of the result of an

1085
00:46:38,050 --> 00:46:34,849
explosion as a core collapse supernova

1086
00:46:40,599 --> 00:46:38,060
there they're like twenty thousand ten

1087
00:46:43,870 --> 00:46:40,609
thousand kilometers per second well when

1088
00:46:46,300 --> 00:46:43,880

you look at a planetary nebula coming

1089
00:46:48,970 --> 00:46:46,310
from a lower mass star the velocities

1090
00:46:51,970 --> 00:46:48,980
are much lower it's ten kilometers per

1091
00:46:55,690 --> 00:46:51,980
second this is a much gentle gentle er

1092
00:46:57,460 --> 00:46:55,700
poof as as Brad was saying of gas going

1093
00:47:00,520 --> 00:46:57,470
off of this this star that will

1094
00:47:03,309 --> 00:47:00,530
eventually become a white dwarf so they

1095
00:47:04,750 --> 00:47:03,319
kind of look different but you know the

1096
00:47:08,079 --> 00:47:04,760
physics is very different with the

1097
00:47:11,260 --> 00:47:08,089
velocities and that's in the gas

1098
00:47:12,339 --> 00:47:11,270
expansion okay great point so I'm gonna

1099
00:47:14,020 --> 00:47:12,349
read this question but I'm going to

1100
00:47:16,210 --> 00:47:14,030
expand it just a little bit because it's

1101
00:47:18,370 --> 00:47:16,220
a really good one and through Parian is

1102
00:47:20,740 --> 00:47:18,380
asking about whether Betelgeuse when it

1103
00:47:23,770 --> 00:47:20,750
goes would it make LIGO wobble and I'm

1104
00:47:27,730 --> 00:47:23,780
going to expand that to say do super

1105
00:47:32,710 --> 00:47:27,740
novae create gravitational waves that's

1106
00:47:35,079 --> 00:47:32,720
a great question and I think that in

1107
00:47:36,940 --> 00:47:35,089
theory they do that this this huge

1108
00:47:38,950 --> 00:47:36,950
change in gravity as you're gonna

1109
00:47:41,800 --> 00:47:38,960
collapse from something the size of the

1110
00:47:44,710 --> 00:47:41,810
earth to ten kilometers down and a

1111
00:47:46,770 --> 00:47:44,720
neutron star you expect a large amount

1112
00:47:49,930 --> 00:47:46,780
of gravitational waves to be emitted

1113
00:47:56,140 --> 00:47:49,940

whether or not Lego will detect that as

1114
00:47:58,630 --> 00:47:56,150
another question so I I think that what

1115
00:48:01,140 --> 00:47:58,640
they've seen already with the merger of

1116
00:48:03,990 --> 00:48:01,150
black holes is something they're kind of

1117
00:48:05,859 --> 00:48:04,000
very tuned for it it produces

1118
00:48:10,089 --> 00:48:05,869
wavelengths of gravitational radiation

1119
00:48:13,000 --> 00:48:10,099
that are fairly narrow and and then it

1120
00:48:15,220 --> 00:48:13,010
gets as they merge it gets higher and

1121
00:48:17,890 --> 00:48:15,230
higher frequency but a very narrow range

1122
00:48:22,079 --> 00:48:17,900
of frequencies think of a supernova

1123
00:48:24,819 --> 00:48:22,089
explosion as more like I know throwing

1124
00:48:28,950 --> 00:48:24,829
spaghetti against the wall you're going

1125
00:48:31,900 --> 00:48:28,960
to get a whole range a whole range of

1126
00:48:33,880 --> 00:48:31,910
frequencies of gravitational radiation

1127
00:48:36,460 --> 00:48:33,890
and that's going to make it actually

1128
00:48:39,430 --> 00:48:36,470
harder to detect than the narrow range

1129
00:48:42,270 --> 00:48:39,440
of frequencies we saw with the black

1130
00:48:46,600 --> 00:48:44,770
but-but-but built on that there is a

1131
00:48:48,970 --> 00:48:46,610
there's a recent study from a friend of

1132
00:48:50,050 --> 00:48:48,980
a colleague of mine who with the

1133
00:48:52,570 --> 00:48:50,060
discovery of gravitational waves

1134
00:48:54,280 --> 00:48:52,580
calculated what a type 1a supernova

1135
00:48:56,830 --> 00:48:54,290
would do for gravitational waves because

1136
00:48:59,410 --> 00:48:56,840
there we believe it's some in some cases

1137
00:49:00,640 --> 00:48:59,420
two white dwarfs that come together to

1138
00:49:02,920 --> 00:49:00,650

blow up and this is something our

1139
00:49:05,140 --> 00:49:02,930
previous Kepler study showed and what

1140
00:49:06,850 --> 00:49:05,150
they saw is not that LIGO would be able

1141
00:49:10,600 --> 00:49:06,860
to see it but the next generation of

1142
00:49:13,210 --> 00:49:10,610
gravitational waves a close enough star

1143
00:49:16,420 --> 00:49:13,220
in a type 1a supernova so kind of within

1144
00:49:19,120 --> 00:49:16,430
our local neighborhood could be detected

1145
00:49:21,730 --> 00:49:19,130
by gravitational waves from a type 1a

1146
00:49:23,920 --> 00:49:21,740
thermonuclear supernova so it gives us

1147
00:49:25,690 --> 00:49:23,930
another way to look for these things you

1148
00:49:27,370 --> 00:49:25,700
know I'm looking for the day we can see

1149
00:49:29,170 --> 00:49:27,380
the neutrinos the gravitational waves

1150
00:49:31,270 --> 00:49:29,180
and the shockwave all from the same

1151
00:49:36,910 --> 00:49:31,280
explosion you just don't need much to

1152
00:49:38,710 --> 00:49:36,920
you so yeah that would be please okay so

1153
00:49:41,620 --> 00:49:38,720
gravitational waves two neutrinos the

1154
00:49:46,210 --> 00:49:41,630
whole gambit yeah it's from Twitter at

1155
00:49:49,270 --> 00:49:46,220
tra hall a TDR TRW well nevermind it so

1156
00:49:50,560 --> 00:49:49,280
I can't pronounce it he's asking what

1157
00:49:53,470 --> 00:49:50,570
does this data mean for our

1158
00:49:55,750 --> 00:49:53,480
understanding of black holes I mean can

1159
00:49:57,210 --> 00:49:55,760
you go through Kepler data and do that

1160
00:49:59,950 --> 00:49:57,220
doing an analysis for maybe

1161
00:50:01,420 --> 00:49:59,960
understanding black holes at all because

1162
00:50:07,000 --> 00:50:01,430
you've already done some core collapse

1163
00:50:09,280 --> 00:50:07,010

stuff so my my feeling is that we you

1164
00:50:14,140 --> 00:50:09,290
know we we could do that if we had many

1165
00:50:16,060 --> 00:50:14,150
many supernovae in the data set but with

1166
00:50:18,670 --> 00:50:16,070
the handful of supernovae that we have

1167
00:50:20,500 --> 00:50:18,680
most of them are going to be producing

1168
00:50:24,310 --> 00:50:20,510
they're mostly going to be lower mass

1169
00:50:28,750 --> 00:50:24,320
stars so a solar masses 215 solar masses

1170
00:50:30,700 --> 00:50:28,760
and generating neutron stars to have a

1171
00:50:33,850 --> 00:50:30,710
chance of seeing stars that produce the

1172
00:50:38,050 --> 00:50:33,860
black holes I think because those stars

1173
00:50:41,440 --> 00:50:38,060
are more rare those massive 30 50 solar

1174
00:50:44,860 --> 00:50:41,450
mass stars I think we're going to need a

1175
00:50:47,260 --> 00:50:44,870
much larger data set of Kepler supernova

1176
00:50:50,920 --> 00:50:47,270
this is kind of where k2 comes and we

1177
00:50:54,040 --> 00:50:50,930
have been looking at supernovae with k2

1178
00:50:57,220 --> 00:50:54,050
and we have several new supernovae

1179
00:50:58,960 --> 00:50:57,230
in that dataset and and so you know if

1180
00:51:01,540 --> 00:50:58,970
we could continue with that that would

1181
00:51:02,680 --> 00:51:01,550
be that would be great well since you

1182
00:51:05,109 --> 00:51:02,690
brought that up I want to go ahead and

1183
00:51:07,390 --> 00:51:05,119
cover you're a part of a group it says

1184
00:51:10,540 --> 00:51:07,400
here that is called the Keppler extra

1185
00:51:15,310 --> 00:51:10,550
galactic survey or and this is one of

1186
00:51:18,760 --> 00:51:15,320
the coolest acronyms ever Keggs rad come

1187
00:51:38,080 --> 00:51:18,770
up with that yeah you're the co I'm not

1188
00:51:39,460 --> 00:51:38,090

surprised that's right so tell us a

1189
00:51:41,320 --> 00:51:39,470
little bit about that what are you guys

1190
00:51:44,770 --> 00:51:41,330
doing at kegs besides looking for five

1191
00:51:47,020 --> 00:51:44,780
o'clock and is this an extension and

1192
00:51:48,880 --> 00:51:47,030
that you know Kepler has been expanded

1193
00:51:52,870 --> 00:51:48,890
to do looking in other parts of the sky

1194
00:51:55,480 --> 00:51:52,880
now so tell us what about kegs so you

1195
00:51:57,580 --> 00:51:55,490
know as Peter said originally Peter and

1196
00:52:00,640 --> 00:51:57,590
I had this 100 galaxies were monitoring

1197
00:52:02,410 --> 00:52:00,650
and then we met these uh the guys from

1198
00:52:03,700 --> 00:52:02,420
Maryland who were doing a few hundred

1199
00:52:05,980 --> 00:52:03,710
galaxies and that's how we did these

1200
00:52:07,270 --> 00:52:05,990
originally with Kepler so we said hey

1201
00:52:09,250 --> 00:52:07,280
it'd be great me both want the same

1202
00:52:12,430 --> 00:52:09,260
things we both want to study galaxies

1203
00:52:14,440 --> 00:52:12,440
why don't we do this with k2o and it's

1204
00:52:16,900 --> 00:52:14,450
actually formed an integral part of k2

1205
00:52:20,080 --> 00:52:16,910
and it's actually very beneficial to k2

1206
00:52:21,760 --> 00:52:20,090
so as you said Kepler stared at the same

1207
00:52:25,260 --> 00:52:21,770
patch of sky for about five years in

1208
00:52:27,760 --> 00:52:25,270
about Cygnus now because of the

1209
00:52:30,460 --> 00:52:27,770
partially broken wheels that forced

1210
00:52:33,070 --> 00:52:30,470
Kepler to point it changes fields every

1211
00:52:34,810 --> 00:52:33,080
85 days and so it looks along the

1212
00:52:38,950 --> 00:52:34,820
ecliptic along the plane of the solar

1213
00:52:41,170 --> 00:52:38,960

system and what happens is every 85 days

1214
00:52:42,640 --> 00:52:41,180
it looks towards the Milky Way so

1215
00:52:44,830 --> 00:52:42,650
towards the Milky Way where there's lots

1216
00:52:47,230 --> 00:52:44,840
of stars to look for stellar

1217
00:52:49,480 --> 00:52:47,240
astrophysics planets but then it looks

1218
00:52:51,580 --> 00:52:49,490
the other 85 days it rotates and it

1219
00:52:53,410 --> 00:52:51,590
looks away from the Milky Way where

1220
00:52:55,300 --> 00:52:53,420
there's not a lot of stars but when you

1221
00:52:58,359 --> 00:52:55,310
look away from the Milky Way you look

1222
00:53:01,060 --> 00:52:58,369
and see lots of galaxies so roughly

1223
00:53:03,880 --> 00:53:01,070
every other field is what we call a

1224
00:53:07,810 --> 00:53:03,890
Keggs field so it's every hour of their

1225
00:53:10,510 --> 00:53:07,820
85 days we monitor about 3,000

1226
00:53:12,520 --> 00:53:10,520
Galaxy so instead of 500 were monitoring

1227
00:53:15,970 --> 00:53:12,530
thousands of galaxies to find this

1228
00:53:19,510 --> 00:53:15,980
because of the power of k2 and Kepler so

1229
00:53:24,160 --> 00:53:19,520
to date we've monitored nearly 22,000

1230
00:53:26,260 --> 00:53:24,170
galaxies with k2 and we found a number

1231
00:53:29,230 --> 00:53:26,270
of supernovae were we're racking up

1232
00:53:31,510 --> 00:53:29,240
supernova fast faster than we can we can

1233
00:53:33,310 --> 00:53:31,520
think about and we have we're in the

1234
00:53:34,690 --> 00:53:33,320
process of working on lots of cool new

1235
00:53:37,900 --> 00:53:34,700
discoveries that you know we hope to

1236
00:53:41,080 --> 00:53:37,910
talk about and maybe future hangouts and

1237
00:53:44,080 --> 00:53:41,090
it's because of this this of this power

1238
00:53:46,630 --> 00:53:44,090

of continuously monitoring we can probe

1239
00:53:49,330 --> 00:53:46,640
these other things so you really do have

1240
00:53:55,840 --> 00:53:49,340
more data on supernovae then I mean you

1241
00:53:58,630 --> 00:53:55,850
guys rock we did we we we have that's

1242
00:53:59,800 --> 00:53:58,640
amazing we're blowing everything out of

1243
00:54:02,110 --> 00:53:59,810
the water and it's quite interesting

1244
00:54:07,020 --> 00:54:02,120
Kepler start as a planetary mission but

1245
00:54:12,910 --> 00:54:11,500
you know imagine you know I know it's

1246
00:54:14,500 --> 00:54:12,920
really been really really remarkable

1247
00:54:16,120 --> 00:54:14,510
well I got a couple more personal needs

1248
00:54:19,660 --> 00:54:16,130
over at a time we only have a few more

1249
00:54:22,570 --> 00:54:19,670
minutes at Joel Edwards is asking about

1250
00:54:27,040 --> 00:54:22,580
V Y Canis Majoris one of our favorite

1251
00:54:29,260 --> 00:54:27,050
hyper Nobby candidates we need this is a

1252
00:54:30,700 --> 00:54:29,270
very very large star and when it does go

1253
00:54:38,290 --> 00:54:30,710
will it leave a black hole or a neutron

1254
00:54:44,680 --> 00:54:38,300
star while you're at it you got two

1255
00:54:50,610 --> 00:54:47,650
we believe that obviously large storms

1256
00:54:53,440 --> 00:54:50,620
like V Y Canis Major could be you know a

1257
00:54:55,450 --> 00:54:53,450
class called luminous blue variable and

1258
00:54:57,220 --> 00:54:55,460
these are stars that actually have

1259
00:54:59,800 --> 00:54:57,230
fooled us into previous supernova

1260
00:55:02,110 --> 00:54:59,810
explosions and so when we say really

1261
00:55:04,690 --> 00:55:02,120
hypernova we just mean a big supernova

1262
00:55:06,940 --> 00:55:04,700
and as Peter pointed out the larger

1263
00:55:08,650 --> 00:55:06,950

stars on we do believe create black

1264
00:55:10,690 --> 00:55:08,660
holes there's even a new theory that

1265
00:55:12,640 --> 00:55:10,700
with the very earliest stars that are a

1266
00:55:13,720 --> 00:55:12,650
couple thousand solar masses we could

1267
00:55:15,970 --> 00:55:13,730
see this with the James Webb Space

1268
00:55:19,060 --> 00:55:15,980
Telescope and in fact we can get a

1269
00:55:21,400 --> 00:55:19,070
supernova that is 50,000 times the mass

1270
00:55:24,220 --> 00:55:21,410
of our Sun so we are looking we

1271
00:55:26,560 --> 00:55:24,230
we'll look for those things but you know

1272
00:55:28,930 --> 00:55:26,570
in hypernova it's essentially the same

1273
00:55:30,400 --> 00:55:28,940
kind of gamut we now have a new class of

1274
00:55:33,100 --> 00:55:30,410
supernovae called superluminous

1275
00:55:35,200 --> 00:55:33,110
supernova and very apt description oh

1276
00:55:40,660 --> 00:55:35,210
we're talking about we see something and

1277
00:55:42,640 --> 00:55:40,670
we just call it what we see it it's

1278
00:55:45,040 --> 00:55:42,650
these are orders of magnitude brighter

1279
00:55:47,140 --> 00:55:45,050
than our current supernovae that we kind

1280
00:55:49,030 --> 00:55:47,150
of came out of nowhere so you know we'll

1281
00:55:53,050 --> 00:55:49,040
probably have hyper superluminous

1282
00:55:54,940 --> 00:55:53,060
supernova in the near future believe

1283
00:55:57,250 --> 00:55:54,950
these are a couple hundred solar mass

1284
00:55:59,920 --> 00:55:57,260
stars that explode so we do believe if

1285
00:56:01,630 --> 00:55:59,930
it blows up it it would create it and it

1286
00:56:07,780 --> 00:56:01,640
would probably create a black hole the

1287
00:56:10,150 --> 00:56:07,790
size we don't know in celebration of

1288
00:56:12,310 --> 00:56:10,160

spring and baseball where we're batting

1289
00:56:18,840 --> 00:56:12,320
a thousand with people who want Jacob

1290
00:56:28,360 --> 00:56:26,020
Moray just the universe which are very

1291
00:56:30,760 --> 00:56:28,370
hot and large and they burn very bright

1292
00:56:32,590 --> 00:56:30,770
and not for very long so interesting

1293
00:56:35,470 --> 00:56:32,600
stars so one more one more comment here

1294
00:56:37,870 --> 00:56:35,480
Christopher Patterson is asking how come

1295
00:56:39,790 --> 00:56:37,880
the core collapse of a type 2 supernova

1296
00:56:41,920 --> 00:56:39,800
is so sudden why don't we see a more

1297
00:56:44,290 --> 00:56:41,930
gradual collapse as the star burns less

1298
00:56:45,970 --> 00:56:44,300
and less fuel and the iron starts to

1299
00:56:48,580 --> 00:56:45,980
pile up that's a good question how come

1300
00:56:51,490 --> 00:56:48,590
it happen so fast it is a good question

1301
00:56:55,270 --> 00:56:51,500
and and I just I've been talking to this

1302
00:56:58,080 --> 00:56:55,280
about my to my students now and it is

1303
00:57:01,960 --> 00:56:58,090
it's funny that the hydrogen burns two

1304
00:57:04,090 --> 00:57:01,970
fuses the helium and this takes a long

1305
00:57:06,550 --> 00:57:04,100
time and then that every step actually

1306
00:57:10,890 --> 00:57:06,560
takes shorter and shorter so the fusion

1307
00:57:15,190 --> 00:57:10,900
to from silicon iron actually takes a

1308
00:57:17,980 --> 00:57:15,200
less than a day and as you build up this

1309
00:57:21,250 --> 00:57:17,990
iron core it's actually supported by the

1310
00:57:23,020 --> 00:57:21,260
same thing that supports white dwarf

1311
00:57:25,300 --> 00:57:23,030
stars it's called electron degeneracy

1312
00:57:27,010 --> 00:57:25,310
it's a quantum mechanical effect that

1313
00:57:28,330 --> 00:57:27,020

that electrons don't like to get too

1314
00:57:31,300 --> 00:57:28,340
close together and they produce a

1315
00:57:35,030 --> 00:57:31,310
pressure but once that iron core reaches

1316
00:57:37,250 --> 00:57:35,040
a size of around 1.4 solar masses

1317
00:57:39,410 --> 00:57:37,260
that that pressure can't hold it up

1318
00:57:42,860 --> 00:57:39,420
anymore and it collapses down in a very

1319
00:57:45,770 --> 00:57:42,870
sudden collapse and and produces all of

1320
00:57:47,960 --> 00:57:45,780
us this the neutrinos and and and the

1321
00:57:51,470 --> 00:57:47,970
bounce and and everything that we see so

1322
00:57:53,900 --> 00:57:51,480
it it is a very quick thing that happens

1323
00:57:56,180 --> 00:57:53,910
and and that's probably why we get the

1324
00:57:59,660 --> 00:57:56,190
the explosions that we see is it really

1325
00:58:02,360 --> 00:57:59,670
needs to be quite fast to explode the

1326
00:58:04,490 --> 00:58:02,370
stars all right well this is Grayson on

1327
00:58:07,490 --> 00:58:04,500
well thank you very much and this has

1328
00:58:10,910 --> 00:58:07,500
been a really great great yeah I want to

1329
00:58:12,620 --> 00:58:10,920
thank you both for taking the time your

1330
00:58:17,180 --> 00:58:12,630
discovery so when you get more supernova

1331
00:58:19,670 --> 00:58:17,190
data will you come back you bet they'll

1332
00:58:24,980 --> 00:58:19,680
give you a hard time but not I just want

1333
00:58:26,300 --> 00:58:24,990
to make sure we're still gonna make you

1334
00:58:28,430 --> 00:58:26,310
and I have known each other a long time

1335
00:58:29,930 --> 00:58:28,440
so you know that we will neutrally make

1336
00:58:31,370 --> 00:58:29,940
fun of each other so there's even things

1337
00:58:38,860 --> 00:58:31,380
out we need to do it at 4:00 in the

1338
00:58:41,690 --> 00:58:38,870

morning let's not forget the kegs

1339
00:58:43,670 --> 00:58:41,700
toriana I'll just stay up because it'll

1340
00:58:45,400 --> 00:58:43,680
be 1 a.m. here I'll just stay up all

1341
00:58:49,910 --> 00:58:45,410
night yeah good idea

1342
00:58:52,010 --> 00:58:49,920
absolutely okay thank you really enjoyed

1343
00:58:53,750 --> 00:58:52,020
it thank you so that is the end of this

1344
00:58:55,220 --> 00:58:53,760
one and we want to I think Carol we've

1345
00:59:01,310 --> 00:58:55,230
got a couple lined up now don't wait

1346
00:59:06,490 --> 00:59:01,320
what do we have okay Hubble's fans you

1347
00:59:11,210 --> 00:59:06,500
know what your kids the anniversary

1348
00:59:12,800 --> 00:59:11,220
about the anniversary every so we'll

1349
00:59:14,990 --> 00:59:12,810
have the Hubble anniversary and we'll

1350
00:59:17,630 --> 00:59:15,000
talk about that and we will have maybe

1351
00:59:19,940 --> 00:59:17,640
something nice to look at to discuss

1352
00:59:22,190 --> 00:59:19,950
that awesome great so that'll be next

1353
00:59:24,380 --> 00:59:22,200
weekend yeah you'd have these

1354
00:59:26,930 --> 00:59:24,390
anniversaries is something odd like 26

1355
00:59:29,480 --> 00:59:26,940
and a half anniversary you know that'll

1356
00:59:32,230 --> 00:59:29,490
be you can do that what I can be that

1357
00:59:44,660 --> 00:59:32,240
girlfriend for Hubble like oh it's our

1358
00:59:48,559 --> 00:59:44,670
26th quarter month no I think okay

1359
00:59:53,539 --> 00:59:50,839
Peter thank you very much Peter gonna

1360
00:59:56,569 --> 00:59:53,549
from the from Notre Dame and Brad

1361
01:00:00,620 --> 00:59:56,579
Tucker thank you both very much thank

1362
01:00:02,900 --> 01:00:00,630
you so much we will see folks next week

1363
01:00:05,059 --> 01:00:02,910

same couple time same channel same

1364
01:00:07,189 --> 01:00:05,069
everything so we will talk to you next