
HUBBLE
hangouts
All Things Supernovae!
Wednesday, September 10 2014, 3pm EDT, 7pm UTC

1
00:00:12,009 --> 00:00:08,829
hello everybody and welcome to our

2
00:00:13,810 --> 00:00:12,019
latest Hubble hangout we are back from

3
00:00:16,330 --> 00:00:13,820
our two-week summer break thank you guys

4
00:00:18,370 --> 00:00:16,340
for watching today my name is Tony

5
00:00:20,020 --> 00:00:18,380
Darnell I work at the Space Telescope

6
00:00:21,580 --> 00:00:20,030
Science Institute and today we have a

7
00:00:24,040 --> 00:00:21,590
really great hangout planned for you

8
00:00:26,950 --> 00:00:24,050
today today we have a hangout plan today

9
00:00:30,040 --> 00:00:26,960
okay so I'm gonna be redundant also but

10
00:00:47,200 --> 00:00:30,050
today we're gonna find it today all

11
00:00:49,420 --> 00:00:47,210
right what sounds like you plan my group

12
00:00:52,450 --> 00:00:49,430
there so today's topic we're going to be

13
00:00:54,520 --> 00:00:52,460

talking about super novae what they are

14
00:00:56,380 --> 00:00:54,530
the basics of them and some of the

15
00:00:57,960 --> 00:00:56,390
latest research with supernova

16
00:01:00,000 --> 00:00:57,970
explosions we have a panel of

17
00:01:02,799 --> 00:01:00,010
astronomers here to help us with that

18
00:01:05,410 --> 00:01:02,809
joining me this week as they always do

19
00:01:06,580 --> 00:01:05,420
is dr. Carol Christians from she's from

20
00:01:09,789 --> 00:01:06,590
the Space Telescope Science Institute

21
00:01:11,139 --> 00:01:09,799
also Oh welcome Carol Jeff did you have

22
00:01:14,529 --> 00:01:11,149
a good vacation you have a good time off

23
00:01:17,109 --> 00:01:14,539
absolutely yeah okay also is Scott Lewis

24
00:01:18,999 --> 00:01:17,119
from know the cosmos comm and he's are

25
00:01:20,559 --> 00:01:19,009
all over the place in the internet doing

26
00:01:22,330 --> 00:01:20,569
all kinds of awesome things welcome back

27
00:01:25,510 --> 00:01:22,340
Scott it's good to see you again yes

28
00:01:30,639 --> 00:01:25,520
good to see you too I've missed you yes

29
00:01:33,279 --> 00:01:30,649
I've missed ya I haven't missed you guys

30
00:01:41,109 --> 00:01:33,289
at all I've missed you Carol I don't

31
00:01:44,679 --> 00:01:41,119
care what you say okay this is something

32
00:01:46,300 --> 00:01:44,689
rusty okay so today I said today we are

33
00:01:49,330 --> 00:01:46,310
going to be talking about supernovae and

34
00:01:52,359 --> 00:01:49,340
we want you to interact with us and the

35
00:01:55,029 --> 00:01:52,369
way you can do that is Hubble hangout

36
00:01:57,639 --> 00:01:55,039
hashtag on Twitter the Q&A app on

37
00:01:58,929 --> 00:01:57,649
YouTube and Google+ and the Google+

38
00:02:00,909 --> 00:01:58,939

event page we hope you'll leave us

39
00:02:03,209 --> 00:02:00,919
questions and comments also we're

40
00:02:07,480 --> 00:02:03,219
noticing that there is a new thing on

41
00:02:09,639 --> 00:02:07,490
the Google Hangouts on air interface

42
00:02:12,280 --> 00:02:09,649
there's a little pair of hands where you

43
00:02:13,030 --> 00:02:12,290
can I guess do something applaud or

44
00:02:13,559 --> 00:02:13,040
something like that

45
00:02:17,520 --> 00:02:13,569
so let

46
00:02:18,959 --> 00:02:17,530
feel free to use that and whatever that

47
00:02:20,069 --> 00:02:18,969
thing does I don't know what it is yet

48
00:02:21,509 --> 00:02:20,079
we also have we're going to be

49
00:02:23,190 --> 00:02:21,519
experimenting with this thing called a

50
00:02:24,690 --> 00:02:23,200
showcase where we're gonna try and show

51
00:02:26,520 --> 00:02:24,700
you some new things during the Hangout

52
00:02:29,149 --> 00:02:26,530
as well all of that will be a little bit

53
00:02:32,849 --> 00:02:29,159
experimental so let's get on with it

54
00:02:34,379 --> 00:02:32,859
supernovae explosions that's what we're

55
00:02:38,849 --> 00:02:34,389
here to talk about today and they are

56
00:02:40,979 --> 00:02:38,859
among some of the brightest events that

57
00:02:44,580 --> 00:02:40,989
occur in the universe they are these

58
00:02:48,390 --> 00:02:44,590
they are these deaths of of stars that

59
00:02:51,509 --> 00:02:48,400
are for a brief period of time are can

60
00:02:53,429 --> 00:02:51,519
outshine an entire galaxy in fact they

61
00:02:56,699 --> 00:02:53,439
will put out more energy in a few weeks

62
00:02:58,709 --> 00:02:56,709
in a few months then the Sun will in its

63
00:03:02,250 --> 00:02:58,719

entire lifetime so these are very

64
00:03:03,569 --> 00:03:02,260
energetic events they occur at a rate

65
00:03:04,830 --> 00:03:03,579
which we will talk about a little bit

66
00:03:06,599 --> 00:03:04,840
later on I don't want to give away too

67
00:03:08,520 --> 00:03:06,609
many punch lines because I just want to

68
00:03:10,080 --> 00:03:08,530
give some background on the kinds of

69
00:03:13,439 --> 00:03:10,090
things we're talking about not all stars

70
00:03:15,179 --> 00:03:13,449
blow up some only certain certain ones

71
00:03:17,159 --> 00:03:15,189
do there's also different types of stars

72
00:03:19,559 --> 00:03:17,169
so that explosions that can happen and

73
00:03:22,170 --> 00:03:19,569
to talk about all of these details today

74
00:03:25,530 --> 00:03:22,180
we have a panel of expert astronomers

75
00:03:28,619 --> 00:03:25,540
and let me introduce them first from

76
00:03:31,949 --> 00:03:28,629
Rutgers an astronomer so rube sir Rob is

77
00:03:34,830 --> 00:03:31,959
it Jah Jah yeah not great I love that

78
00:03:36,449 --> 00:03:34,840
when it'll screw it up too bad he's an

79
00:03:38,789 --> 00:03:36,459
astronomer at Rutgers University also

80
00:03:41,399 --> 00:03:38,799
with us is Ryan Foley a professor at the

81
00:03:43,199 --> 00:03:41,409
at the of astronomy at the University of

82
00:03:44,819 --> 00:03:43,209
Illinois a place RI was spent a couple

83
00:03:47,640 --> 00:03:44,829
of years so it's nice to see somebody

84
00:03:51,330 --> 00:03:47,650
from U of I there also Curtis McCauley

85
00:03:53,879 --> 00:03:51,340
he's a postdoc at you just say where are

86
00:03:57,270 --> 00:03:53,889
you from Curtis so I'm at LC OGT and

87
00:03:59,610 --> 00:03:57,280
UCSB so LC OTT is Las Cumbres Global

88
00:04:02,399 --> 00:03:59,620

Telescope and UCSB is University of

89
00:04:05,009 --> 00:04:02,409
California Santa Barbara ah okay thank

90
00:04:07,559 --> 00:04:05,019
you and welcome to all three of you so

91
00:04:10,140 --> 00:04:07,569
let me let me start with you I'm sort of

92
00:04:12,869 --> 00:04:10,150
Saurabh can you give us some background

93
00:04:16,259 --> 00:04:12,879
some basics on what supernova explosions

94
00:04:18,360 --> 00:04:16,269
are so that's great and supernovae are

95
00:04:20,969 --> 00:04:18,370
exploding stars so we have this word and

96
00:04:23,580 --> 00:04:20,979
even the word sometimes trips people up

97
00:04:25,950 --> 00:04:23,590
so we usually say one is a supernova

98
00:04:27,149 --> 00:04:25,960
with just an a at the end and if you

99
00:04:27,360 --> 00:04:27,159
were talking about more than one then

100
00:04:30,390 --> 00:04:27,370
that

101
00:04:33,480 --> 00:04:30,400
super novae with AE it's just funny a

102
00:04:35,670 --> 00:04:33,490
Greek Latin hybrid thing so the New York

103
00:04:37,200 --> 00:04:35,680
Times calls them supernovas so feel free

104
00:04:45,060 --> 00:04:37,210
to call them supernovas as well that's

105
00:04:47,600 --> 00:04:45,070
totally fine no no super oh yeah you

106
00:04:49,980 --> 00:04:47,610
have to say super no because it's fine

107
00:04:51,090 --> 00:04:49,990
yeah so they're exploiting stars and I

108
00:04:52,890 --> 00:04:51,100
as you said right at the end of their

109
00:04:55,320 --> 00:04:52,900
lives some stars explode and I guess

110
00:04:56,550 --> 00:04:55,330
we'll get into which ones do and there

111
00:04:57,930 --> 00:04:56,560
are few of many different kinds and

112
00:04:59,700 --> 00:04:57,940
we're trying to figure out what kind of

113
00:05:01,200 --> 00:04:59,710

stars turn into what kind of explosions

114
00:05:03,210 --> 00:05:01,210
and the Hubble Space Telescope has

115
00:05:04,890 --> 00:05:03,220
helped a lot with that now we know a lot

116
00:05:06,960 --> 00:05:04,900
about supernovae already I mean we've

117
00:05:08,820 --> 00:05:06,970
been seeing them for thousands of years

118
00:05:10,830 --> 00:05:08,830
I think the first recorded supernova as

119
00:05:15,420 --> 00:05:10,840
I was we're always taught in astronomy

120
00:05:17,070 --> 00:05:15,430
101 was in 1054 right yeah there may be

121
00:05:18,920 --> 00:05:17,080
some records even before that but yeah

122
00:05:22,020 --> 00:05:18,930
1054 we have a pretty well-documented

123
00:05:24,779 --> 00:05:22,030
one and you can go back to look at

124
00:05:28,670 --> 00:05:24,789
records that people kept in China and

125
00:05:31,830 --> 00:05:28,680
Japan saying on in fact on July 4th 1054

126
00:05:34,440 --> 00:05:31,840
before the fireworks absolutely but

127
00:05:36,629 --> 00:05:34,450
there were some celestial fireworks that

128
00:05:42,480 --> 00:05:36,639
day I think that's a plug for murica

129
00:05:45,659 --> 00:05:42,490
though it was a premonition of great

130
00:05:47,100 --> 00:05:45,669
things to come in in America yeah and

131
00:05:49,200 --> 00:05:47,110
then actually what the amazing thing is

132
00:05:50,520 --> 00:05:49,210
now we can go back and you know they the

133
00:05:52,469 --> 00:05:50,530
astronomers at that time kept really

134
00:05:54,839 --> 00:05:52,479
good records of where that new star

135
00:05:57,150 --> 00:05:54,849
occurred and we can go back and look at

136
00:05:58,589 --> 00:05:57,160
that right now and when we go there we

137
00:06:00,120 --> 00:05:58,599
point for instance Hubble there there

138
00:06:02,610 --> 00:06:00,130

are beautiful images of the Crab Nebula

139
00:06:05,820 --> 00:06:02,620
so we can see now the Stars ground up

140
00:06:07,980 --> 00:06:05,830
now that exploded in 1054 so you know

141
00:06:09,180 --> 00:06:07,990
almost a thousand years later we can see

142
00:06:11,460 --> 00:06:09,190
what it looks like so it's pretty

143
00:06:12,779 --> 00:06:11,470
amazing and this this would have looked

144
00:06:14,310 --> 00:06:12,789
this would have been something they

145
00:06:15,960 --> 00:06:14,320
people could have well obviously they

146
00:06:18,180 --> 00:06:15,970
did look up and see it in their own

147
00:06:19,680 --> 00:06:18,190
night sky and I believe they're saying

148
00:06:21,480 --> 00:06:19,690
it was bright enough to be seen during

149
00:06:22,800 --> 00:06:21,490
the day is that correct yeah I think

150
00:06:25,409 --> 00:06:22,810
that is true yeah and it's in the

151
00:06:27,629 --> 00:06:25,419
constellation of Taurus I think and you

152
00:06:29,129 --> 00:06:27,639
know usually at that time new stars in

153
00:06:31,080 --> 00:06:29,139
the skies but that was usually bad for

154
00:06:33,810 --> 00:06:31,090
the king or the Emperor or whatever it

155
00:06:35,820 --> 00:06:33,820
was a usually a bad omen but for us in

156
00:06:38,640 --> 00:06:35,830
astronomy reluctancy stars explode and

157
00:06:40,540 --> 00:06:38,650
see what they're made of and even enrich

158
00:06:42,430 --> 00:06:40,550
the universe with all that stuff

159
00:06:45,640 --> 00:06:42,440
comments have that same reputation so

160
00:06:50,020 --> 00:06:45,650
all right so not but not the supernova

161
00:06:52,300 --> 00:06:50,030
explosions are a a way in which a star

162
00:06:53,830 --> 00:06:52,310
can die now most people know and if you

163
00:06:55,900 --> 00:06:53,840

don't I'll remind you that stars burn

164
00:06:59,800 --> 00:06:55,910
through a nuclear fusion they have these

165
00:07:02,650 --> 00:06:59,810
these us is that make let them shine and

166
00:07:04,810 --> 00:07:02,660
it's very complicated and and in and

167
00:07:06,880 --> 00:07:04,820
they generate a lot lot of energy but

168
00:07:09,970 --> 00:07:06,890
stars also come in different shapes and

169
00:07:12,820 --> 00:07:09,980
sizes and colors and temperatures what

170
00:07:14,830 --> 00:07:12,830
kind of stars in their life this way and

171
00:07:18,360 --> 00:07:14,840
let me let me get the Ryan in on this

172
00:07:25,570 --> 00:07:18,370
how about can you take that one for me

173
00:07:28,210 --> 00:07:25,580
well you're muted I think sorry so what

174
00:07:31,060 --> 00:07:28,220
so first of all what we think is just

175
00:07:33,370 --> 00:07:31,070
about every star that's particularly

176
00:07:35,980 --> 00:07:33,380
massive say you know something that's

177
00:07:38,830 --> 00:07:35,990
ten times as massive as our Sun or even

178
00:07:41,230 --> 00:07:38,840
more will probably explode as a

179
00:07:43,660 --> 00:07:41,240
supernova there's there's some actually

180
00:07:45,880 --> 00:07:43,670
really interesting theoretical idea is

181
00:07:47,830 --> 00:07:45,890
that maybe they'll some subset will

182
00:07:49,660 --> 00:07:47,840
collapse directly to a black hole and

183
00:07:51,760 --> 00:07:49,670
not have a supernova at the end of its

184
00:07:53,620 --> 00:07:51,770
life but the vast majority should and

185
00:07:57,940 --> 00:07:53,630
we've seen this because we've been able

186
00:07:59,380 --> 00:07:57,950
to detect stars after they occur we have

187
00:08:01,540 --> 00:07:59,390
seen the explosion we've gone back at

188
00:08:03,580 --> 00:08:01,550

our old images and seeing the stars

189
00:08:05,620 --> 00:08:03,590
there and then we see the Superdome and

190
00:08:07,480 --> 00:08:05,630
then we look much later and we see that

191
00:08:11,560 --> 00:08:07,490
the star is gone so we know that that's

192
00:08:14,440 --> 00:08:11,570
happened then there are less massive

193
00:08:16,690 --> 00:08:14,450
stars that eventually after going

194
00:08:19,320 --> 00:08:16,700
through this full process of living

195
00:08:21,670 --> 00:08:19,330
their lives kind of like our Sun and

196
00:08:23,140 --> 00:08:21,680
going on to another stage called like

197
00:08:25,120 --> 00:08:23,150
the red the red giant stage where

198
00:08:27,810 --> 00:08:25,130
they're really big and and puffy and

199
00:08:29,920 --> 00:08:27,820
then eventually becoming a white dwarf a

200
00:08:32,920 --> 00:08:29,930
white dwarf is essentially just the

201
00:08:35,410 --> 00:08:32,930
center of that star after all of the

202
00:08:38,200 --> 00:08:35,420
nuclear fusion has has happened and it's

203
00:08:40,810 --> 00:08:38,210
just slowly cooling down but a subset of

204
00:08:43,900 --> 00:08:40,820
white dwarfs that are in systems with

205
00:08:47,320 --> 00:08:43,910
another star very nearby and gain some

206
00:08:49,720 --> 00:08:47,330
mass from that other star and eventually

207
00:08:51,550 --> 00:08:49,730
get to conditions inside the star where

208
00:08:53,710 --> 00:08:51,560
you can restart nuclear fusion

209
00:08:53,920 --> 00:08:53,720
but you restarted in a way where the new

210
00:08:56,920 --> 00:08:53,930
clue

211
00:09:01,139 --> 00:08:56,930
is a runaway it causes a major explosion

212
00:09:03,700 --> 00:09:01,149
and that will result in a supernova so

213
00:09:06,639 --> 00:09:03,710

those are the two main categories of

214
00:09:08,560 --> 00:09:06,649
stellar explosions and there and the big

215
00:09:10,389 --> 00:09:08,570
lint the big factor here to determine is

216
00:09:12,160 --> 00:09:10,399
whether a star explodes or not is it

217
00:09:14,500 --> 00:09:12,170
sighs I think you said ten times the

218
00:09:16,660 --> 00:09:14,510
mass of our Sun right yeah so so you

219
00:09:18,790 --> 00:09:16,670
know there's that one of the very

220
00:09:21,280 --> 00:09:18,800
important areas of research right now is

221
00:09:23,470 --> 00:09:21,290
determining the exact minimum maths the

222
00:09:26,350 --> 00:09:23,480
smallest star can be and explode in that

223
00:09:28,690 --> 00:09:26,360
way and and most people kind of are

224
00:09:32,139 --> 00:09:28,700
pinning it around eight times the mass

225
00:09:34,570 --> 00:09:32,149
of the Sun but you know 10 we we will

226
00:09:37,180 --> 00:09:34,580
see that thing explode for the most part

227
00:09:40,930 --> 00:09:37,190
but yeah and it's the it's it's actually

228
00:09:44,079 --> 00:09:40,940
the the mass of the core near the end of

229
00:09:47,050 --> 00:09:44,089
its life not necessarily how much how

230
00:09:48,519 --> 00:09:47,060
big the star is when when it's more like

231
00:09:50,560 --> 00:09:48,529
the the Sun when it's burning hydrogen

232
00:09:53,560 --> 00:09:50,570
into helium it's really at the end that

233
00:09:55,480 --> 00:09:53,570
matters I but that's the technicality

234
00:09:57,940 --> 00:09:55,490
for the most part we can you know if you

235
00:09:59,860 --> 00:09:57,950
starts off at ten times it'll explode

236
00:10:01,269 --> 00:09:59,870
okay so one thing I want to clarify is

237
00:10:03,610 --> 00:10:01,279
you said that there are two ways they

238
00:10:07,030 --> 00:10:03,620

can be triggered and one of them had to

239
00:10:09,280 --> 00:10:07,040
do with the white dwarf being re somehow

240
00:10:11,860 --> 00:10:09,290
reignited or somehow fusion processes

241
00:10:14,170 --> 00:10:11,870
being restarted again and that exploded

242
00:10:16,840 --> 00:10:14,180
right so yeah is there two explosions

243
00:10:18,850 --> 00:10:16,850
then well no so these are two separate

244
00:10:22,420 --> 00:10:18,860
events completely so one are the very

245
00:10:25,210 --> 00:10:22,430
massive stars that they look they they

246
00:10:27,480 --> 00:10:25,220
blow up because eventually what what

247
00:10:29,500 --> 00:10:27,490
ends up happening is that the the

248
00:10:32,680 --> 00:10:29,510
diffusion in the in the core of that

249
00:10:35,410 --> 00:10:32,690
star is no longer able to counteract the

250
00:10:37,150 --> 00:10:35,420
force of gravity and and so the star

251
00:10:39,970 --> 00:10:37,160
collapses in on itself and that can

252
00:10:42,190 --> 00:10:39,980
cause an explosion and it's that release

253
00:10:43,780 --> 00:10:42,200
that like you know nearly instantaneous

254
00:10:46,449 --> 00:10:43,790
release of gravitational energy that's

255
00:10:49,780 --> 00:10:46,459
that's very explodes to that explosion

256
00:10:54,250 --> 00:10:49,790
Wow for the white dwarf on the other

257
00:10:57,519 --> 00:10:54,260
hand if if you slowly add material to it

258
00:10:58,930 --> 00:10:57,529
it'll become more massive and because

259
00:11:00,400 --> 00:10:58,940
it's more massive and a white dwarf is a

260
00:11:02,650 --> 00:11:00,410
very funny object that's called a

261
00:11:04,780 --> 00:11:02,660
degenerate object we don't need to get

262
00:11:07,510 --> 00:11:04,790
into the details of it but what it means

263
00:11:10,300 --> 00:11:07,520

is that the more massive it becomes the

264
00:11:12,610 --> 00:11:10,310
it actually gets and so the density goes

265
00:11:14,980 --> 00:11:12,620
really it goes up a lot because you're

266
00:11:17,860 --> 00:11:14,990
making it the mass higher and the the

267
00:11:19,930 --> 00:11:17,870
size of it smaller so as the density

268
00:11:22,810 --> 00:11:19,940
increases eventually you get to a point

269
00:11:24,280 --> 00:11:22,820
where you you have so many carbon atoms

270
00:11:26,950 --> 00:11:24,290
that are really close together that the

271
00:11:28,420 --> 00:11:26,960
carbon will will fuse together and when

272
00:11:30,340 --> 00:11:28,430
that happens when you when you take it

273
00:11:32,140 --> 00:11:30,350
you know carbon atom carbon atom and you

274
00:11:35,500 --> 00:11:32,150
fuse them together that's nuclear fusion

275
00:11:37,510 --> 00:11:35,510
it releases energy and the conditions of

276
00:11:39,310 --> 00:11:37,520
the weight or if are such that you know

277
00:11:41,110 --> 00:11:39,320
once you start that process it becomes a

278
00:11:44,640 --> 00:11:41,120
runaway and it'll burn through the

279
00:11:47,680 --> 00:11:44,650
entire star and that explosion is is

280
00:11:49,840 --> 00:11:47,690
it's what we call a supernova as well so

281
00:11:51,400 --> 00:11:49,850
you described white dwarves as

282
00:11:53,260 --> 00:11:51,410
degenerate stars and I love that because

283
00:11:56,850 --> 00:11:53,270
anytime we can use that word in

284
00:11:59,050 --> 00:11:56,860
astronomy it makes me laugh but the the

285
00:12:02,160 --> 00:11:59,060
where did the white dwarf come from to

286
00:12:05,470 --> 00:12:02,170
be able to have that happen right so

287
00:12:08,230 --> 00:12:05,480
again the white dwarf is sort of the the

288
00:12:10,780 --> 00:12:08,240

end of life for most starts the star

289
00:12:12,340 --> 00:12:10,790
like our Sun after it burns all the

290
00:12:13,480 --> 00:12:12,350
hydrogen into helium and then it goes

291
00:12:16,270 --> 00:12:13,490
through this other phase where it'll

292
00:12:18,340 --> 00:12:16,280
burn the helium that that it generates

293
00:12:21,340 --> 00:12:18,350
now into heavier elements like carbon

294
00:12:22,990 --> 00:12:21,350
and oxygen eventually because it's not

295
00:12:24,610 --> 00:12:23,000
so massive it can't continue to burn

296
00:12:27,520 --> 00:12:24,620
heavier heavier elements and it just

297
00:12:29,860 --> 00:12:27,530
stops and the core of That star after

298
00:12:31,960 --> 00:12:29,870
that fusion has essentially stopped is

299
00:12:34,990 --> 00:12:31,970
then the white dwarf and a white dwarf

300
00:12:37,660 --> 00:12:35,000
is about the size of the earth you know

301
00:12:39,580 --> 00:12:37,670
it's it's not huge but much bigger than

302
00:12:40,780 --> 00:12:39,590
you know what the universe is my

303
00:12:43,090 --> 00:12:40,790
confusion though used to this that's

304
00:12:45,760 --> 00:12:43,100
what's gonna happen to our son yes but

305
00:12:49,150 --> 00:12:45,770
Marcelle never explode eight eight solar

306
00:12:52,870 --> 00:12:49,160
masses or greater so how can a star that

307
00:12:54,520 --> 00:12:52,880
big get a do they make orbs to I'm yeah

308
00:12:55,990 --> 00:12:54,530
suit so if you're above if you're above

309
00:12:57,070 --> 00:12:56,000
ten solar masses you'll never get to a

310
00:12:59,140 --> 00:12:57,080
white dwarf because you'll have a

311
00:13:00,700 --> 00:12:59,150
supernova before that can happen okay so

312
00:13:02,860 --> 00:13:00,710
this subset that we're talking about

313
00:13:07,450 --> 00:13:02,870

this white dwarf or a supernova

314
00:13:09,070 --> 00:13:07,460
yes is nowhere near as common he's not

315
00:13:12,280 --> 00:13:09,080
telling you part of this story

316
00:13:14,680 --> 00:13:12,290
oh not telling you about the companion

317
00:13:17,530 --> 00:13:14,690
oh I told you about the compare we do

318
00:13:19,390 --> 00:13:17,540
hear it okay say again so we're

319
00:13:23,070 --> 00:13:19,400
envisioning this white dwarf like the

320
00:13:30,700 --> 00:13:27,640
that's where the extra stuff so that the

321
00:13:32,680 --> 00:13:30,710
Sun will never explode and most white

322
00:13:35,740 --> 00:13:32,690
dwarfs will never explode only a small

323
00:13:37,900 --> 00:13:35,750
subset that have companions and the

324
00:13:40,240 --> 00:13:37,910
conditions have to be right so that you

325
00:13:42,760 --> 00:13:40,250
can transfer some of the material from

326
00:13:45,460 --> 00:13:42,770
the companion to the white dwarf in the

327
00:13:47,830 --> 00:13:45,470
right way and if you do everything just

328
00:13:49,720 --> 00:13:47,840
right then you get a supernova okay good

329
00:13:51,250 --> 00:13:49,730
there we go I just want to make that

330
00:13:54,550 --> 00:13:51,260
case god I don't know if you have it

331
00:13:58,120 --> 00:13:54,560
handy but there was a graphic of that I

332
00:13:59,500 --> 00:13:58,130
think sent by Curtis pointing that look

333
00:14:01,300 --> 00:13:59,510
just sort of an artist rendition of what

334
00:14:05,320 --> 00:14:01,310
that looks like but you can't find

335
00:14:07,090 --> 00:14:05,330
that's okay but in terms of how common

336
00:14:09,130 --> 00:14:07,100
each of these subs you know each of

337
00:14:12,340 --> 00:14:09,140
these types of supernovae are they're

338
00:14:14,410 --> 00:14:12,350

roughly the same although the the kind

339
00:14:17,680 --> 00:14:14,420
from more massive stars are slightly

340
00:14:20,760 --> 00:14:17,690
more common in terms of how often they

341
00:14:23,800 --> 00:14:20,770
occur but just because of the the

342
00:14:25,390 --> 00:14:23,810
characteristics of of the explosions the

343
00:14:27,730 --> 00:14:25,400
the white dwarf supernovae tend to be

344
00:14:33,580 --> 00:14:27,740
brighter and so we find more of them

345
00:14:34,840 --> 00:14:33,590
generally they're brighter okay so so

346
00:14:36,040 --> 00:14:34,850
before we leave this topic and while

347
00:14:38,140 --> 00:14:36,050
we're on that we've mentioned our own

348
00:14:39,250 --> 00:14:38,150
Sun a couple of times Curtis can I let

349
00:14:40,210 --> 00:14:39,260
me get you in the conversation a little

350
00:14:42,300 --> 00:14:40,220
bit let me ask you

351
00:14:44,740 --> 00:14:42,310
we've already just we've already our

352
00:14:47,620 --> 00:14:44,750
Ryan's already told us that our Suns not

353
00:14:49,210 --> 00:14:47,630
going to blow up what will it do so at

354
00:14:50,770 --> 00:14:49,220
the end of its life it's going to

355
00:14:51,880 --> 00:14:50,780
transition from burning hydrogen into

356
00:14:54,100 --> 00:14:51,890
start and it's going to start burning

357
00:14:55,690 --> 00:14:54,110
helium in the core and it's going to as

358
00:14:59,260 --> 00:14:55,700
Ryan mentioned before it's going to puff

359
00:15:01,090 --> 00:14:59,270
up into a red giant and kind of at the

360
00:15:03,010 --> 00:15:01,100
end of all of this cycle it's going to

361
00:15:04,630 --> 00:15:03,020
blow off the outer layers kind of puff

362
00:15:07,600 --> 00:15:04,640
off the outer layers I'm not really an

363
00:15:10,240 --> 00:15:07,610

explosion but something a little gentler

364
00:15:11,650 --> 00:15:10,250
and it's going to create something that

365
00:15:13,930 --> 00:15:11,660
looks like a nebula and what's going to

366
00:15:16,510 --> 00:15:13,940
be left is a carbon and oxygen white

367
00:15:18,730 --> 00:15:16,520
dwarf okay so Scott put you you had it

368
00:15:21,100 --> 00:15:18,740
up briefly can you show one more time

369
00:15:23,830 --> 00:15:21,110
I'm gonna put this up all curtis's to

370
00:15:26,110 --> 00:15:23,840
illustrate this point so our Sun when it

371
00:15:28,330 --> 00:15:26,120
goes when it dies we'll leave behind a

372
00:15:31,230 --> 00:15:28,340
white dwarf star this won't be what

373
00:15:33,670 --> 00:15:31,240
happens in our particular case but the

374
00:15:34,670 --> 00:15:33,680
some white dwarfs have a companion a

375
00:15:37,040 --> 00:15:34,680
nearby star

376
00:15:39,260 --> 00:15:37,050
are from which it can draw material and

377
00:15:41,120 --> 00:15:39,270
here's the cartoon showing that now that

378
00:15:42,800 --> 00:15:41,130
Scott has up and you can see there's a

379
00:15:45,860 --> 00:15:42,810
there's a big much bigger star

380
00:15:48,139 --> 00:15:45,870
surrounding and orbiting in unison with

381
00:15:51,800 --> 00:15:48,149
a with a slower white dwarf these things

382
00:15:52,880 --> 00:15:51,810
are very dense as Ryan pointed out it's

383
00:15:54,530 --> 00:15:52,890
one of those things you hear in high

384
00:15:56,870 --> 00:15:54,540
school all the time 1 tablespoon

385
00:15:59,600 --> 00:15:56,880
spoonful of this stuff will weigh

386
00:16:01,850 --> 00:15:59,610
bajillions of tons and you know your

387
00:16:04,100 --> 00:16:01,860
mind goes like okay that's a lot that's

388
00:16:06,470 --> 00:16:04,110

a big number but suffice it to say these

389
00:16:08,900 --> 00:16:06,480
are dense objects and and here's a

390
00:16:10,990 --> 00:16:08,910
cartoon of what Ryan was talking about

391
00:16:15,350 --> 00:16:11,000
so for supernovae like this to occur

392
00:16:18,910 --> 00:16:15,360
Ryan it has to gather enough matter or

393
00:16:21,880 --> 00:16:18,920
mass from this other star to reignite

394
00:16:24,440 --> 00:16:21,890
fusion within the degenerate star right

395
00:16:27,040 --> 00:16:24,450
yeah that's correct in fact the the

396
00:16:29,630 --> 00:16:27,050
picture that you're showing is a very

397
00:16:31,130 --> 00:16:29,640
particular and very very interesting

398
00:16:35,060 --> 00:16:31,140
especially for the people on this call

399
00:16:36,410 --> 00:16:35,070
type of supernova and and so you're

400
00:16:37,639 --> 00:16:36,420
absolutely right is the same kind of

401
00:16:40,699 --> 00:16:37,649
thing that we've talked about but this

402
00:16:42,590 --> 00:16:40,709
specific example I'm sure will get into

403
00:16:46,100 --> 00:16:42,600
this eventually we think that although

404
00:16:49,070 --> 00:16:46,110
you'll have a runaway nuclear reaction

405
00:16:56,630 --> 00:16:49,080
that will cause an explosion the star

406
00:17:02,390 --> 00:16:56,640
itself may survive so I have I have a

407
00:17:07,730 --> 00:17:02,400
question Carol your hand question I have

408
00:17:09,400 --> 00:17:07,740
to raise my hand but you don't so so I

409
00:17:13,400 --> 00:17:09,410
know you're going to talk about how you

410
00:17:15,500 --> 00:17:13,410
determine in detail using Hubble and

411
00:17:19,329 --> 00:17:15,510
other observatories but the first

412
00:17:22,189 --> 00:17:19,339
question is we know they get bright so

413
00:17:24,230 --> 00:17:22,199

somebody discovers it maybe even

414
00:17:28,280 --> 00:17:24,240
somebody at Las Cumbres discovers a

415
00:17:31,520 --> 00:17:28,290
supernova and then how do you know right

416
00:17:34,070 --> 00:17:31,530
off the bat what type of supernova is

417
00:17:37,100 --> 00:17:34,080
before you decide to start investigating

418
00:17:39,080 --> 00:17:37,110
it in great detail on maybe looking at

419
00:17:41,270 --> 00:17:39,090
its companion oh it's see if it has a

420
00:17:44,000 --> 00:17:41,280
binary star or whatever so how do you

421
00:17:46,460 --> 00:17:44,010
how do we know the type what makes it a

422
00:17:48,320 --> 00:17:46,470
type yeah so there are a bunch of

423
00:17:48,560 --> 00:17:48,330
different types of these supernovae and

424
00:17:50,480 --> 00:17:48,570
there's

425
00:17:52,970 --> 00:17:50,490
sort of two ways that we like to

426
00:17:54,680 --> 00:17:52,980
classify them one is like trying to

427
00:17:56,120 --> 00:17:54,690
understand what kind of system was it

428
00:17:57,950 --> 00:17:56,130
was it a massive star with the first

429
00:17:59,570 --> 00:17:57,960
kind that Ryan mentioned or was it one

430
00:18:01,850 --> 00:17:59,580
of these white dwarf supernovae and so

431
00:18:03,879 --> 00:18:01,860
that's like a physical kind of type what

432
00:18:05,779 --> 00:18:03,889
was the system that exploded

433
00:18:07,580 --> 00:18:05,789
unfortunately we don't usually get to

434
00:18:09,019 --> 00:18:07,590
see the system you know we're not there

435
00:18:11,330 --> 00:18:09,029
so we don't get to see it we just get to

436
00:18:13,249 --> 00:18:11,340
see the light from the system so what we

437
00:18:15,200 --> 00:18:13,259
really get is we usually go and take a

438
00:18:17,419 --> 00:18:15,210

spectrum so we take that light we spread

439
00:18:18,740 --> 00:18:17,429
it out into its colors with Hubble for

440
00:18:21,169 --> 00:18:18,750
instance we can do that especially in

441
00:18:22,490 --> 00:18:21,179
the ultraviolet and other parts of the

442
00:18:24,409 --> 00:18:22,500
spectrum but usually we can also do it

443
00:18:26,869 --> 00:18:24,419
just from the ground-based telescopes in

444
00:18:29,060 --> 00:18:26,879
the visible and then we looked for what

445
00:18:31,639 --> 00:18:29,070
elements are in that spectrum and that

446
00:18:34,430 --> 00:18:31,649
gives us a hint as to what of the which

447
00:18:36,230 --> 00:18:34,440
of these kinds of supernovae they are

448
00:18:37,820 --> 00:18:36,240
what what kind of stories came from

449
00:18:40,789 --> 00:18:37,830
actually for a long time so people have

450
00:18:43,820 --> 00:18:40,799
been doing this for decades and like in

451
00:18:46,249 --> 00:18:43,830
the 50s and 60s people would get CDs new

452
00:18:48,590 --> 00:18:46,259
stars these exploded stars they would

453
00:18:50,299 --> 00:18:48,600
get a spectrum and they would say oh it

454
00:18:52,610 --> 00:18:50,309
looks like it has hydrogen in it we're

455
00:18:53,749 --> 00:18:52,620
gonna call that a type 2 and here's one

456
00:18:55,940 --> 00:18:53,759
that doesn't have hydrogen we're gonna

457
00:18:57,680 --> 00:18:55,950
call that a type 1 and they didn't know

458
00:18:59,299 --> 00:18:57,690
what kind of stars were necessarily

459
00:19:01,129 --> 00:18:59,309
responsible for those two different

460
00:19:03,080 --> 00:19:01,139
types so they just kind of classified

461
00:19:04,940 --> 00:19:03,090
them based on what this spectrum was and

462
00:19:06,860 --> 00:19:04,950
we still do that today so we we have all

463
00:19:10,279 --> 00:19:06,870

these different types the type 1 that

464
00:19:11,899 --> 00:19:10,289
later got subdivided into type 1a 1b 1c

465
00:19:14,149 --> 00:19:11,909
and then type twos and then there are

466
00:19:16,369 --> 00:19:14,159
even some other types that in fact some

467
00:19:18,740 --> 00:19:16,379
of us totally Ryan have helped coin and

468
00:19:20,419 --> 00:19:18,750
the big goal actually in supernova

469
00:19:22,519 --> 00:19:20,429
research is to connect the type of

470
00:19:25,490 --> 00:19:22,529
supernova we see from the data from the

471
00:19:26,810 --> 00:19:25,500
spectrum that we measure - this is or

472
00:19:29,240 --> 00:19:26,820
was it well it one of these massive

473
00:19:30,980 --> 00:19:29,250
stars that are on here now it turns out

474
00:19:33,230 --> 00:19:30,990
that we think the type twos and the one

475
00:19:35,389 --> 00:19:33,240
B's and once C's come from this kind of

476
00:19:37,310 --> 00:19:35,399
massive star configuration whereas the

477
00:19:39,259 --> 00:19:37,320
white dwarf supernovae mostly account

478
00:19:40,639 --> 00:19:39,269
for the type 1a s but that was actually

479
00:19:44,240 --> 00:19:40,649
only knowledge that was sort of gained

480
00:19:45,950 --> 00:19:44,250
through observation and modeling of the

481
00:19:47,509 --> 00:19:45,960
supernovae together to kind of come

482
00:19:49,070 --> 00:19:47,519
together through a consistent picture

483
00:19:51,619 --> 00:19:49,080
but still the forefront of research

484
00:19:54,560 --> 00:19:51,629
connecting the data to what actually

485
00:19:57,409 --> 00:19:54,570
exploded and you have to catch them

486
00:20:00,289 --> 00:19:57,419
pretty quick right I mean you have to

487
00:20:02,210 --> 00:20:00,299
so there are searches to try to find the

488
00:20:04,100 --> 00:20:02,220

supernova and then immediately

489
00:20:05,690 --> 00:20:04,110
we start observing them as because you

490
00:20:08,330 --> 00:20:05,700
want to catch them as close as you can

491
00:20:10,640 --> 00:20:08,340
to when they go up right that's right

492
00:20:12,289 --> 00:20:10,650
yeah I mean the earlier you can you can

493
00:20:14,210 --> 00:20:12,299
see them you can see different parts of

494
00:20:15,740 --> 00:20:14,220
the supernova actually as time goes on

495
00:20:17,299 --> 00:20:15,750
you usually can see deeper and deeper

496
00:20:20,360 --> 00:20:17,309
into the supernova so you learn about

497
00:20:21,649 --> 00:20:20,370
the structure so in that massive star

498
00:20:23,779 --> 00:20:21,659
diagram where you have that kind of

499
00:20:25,490 --> 00:20:23,789
onion skin structure you can see

500
00:20:28,640 --> 00:20:25,500
different elements in different layers

501
00:20:30,020 --> 00:20:28,650
of the deeper but one of the important

502
00:20:32,060 --> 00:20:30,030
reasons to you know try and study them

503
00:20:33,529 --> 00:20:32,070
one day when you first go off is because

504
00:20:34,909 --> 00:20:33,539
they're they're usually not too much you

505
00:20:36,680 --> 00:20:34,919
know they may take a couple weeks to get

506
00:20:38,210 --> 00:20:36,690
to their peak brightness but after that

507
00:20:39,500 --> 00:20:38,220
it's all downhill so you want to study

508
00:20:41,029 --> 00:20:39,510
them when they're bright when we can

509
00:20:43,850 --> 00:20:41,039
collect the most light from them and

510
00:20:45,380 --> 00:20:43,860
learn the most about them okay so I also

511
00:20:46,880 --> 00:20:45,390
Curtis you had a diagram of the

512
00:20:52,970 --> 00:20:46,890
different types can you put that back up

513
00:20:54,080 --> 00:20:52,980

please so there so there are well let's

514
00:20:55,430 --> 00:20:54,090
just talk about all the different cut

515
00:20:56,930 --> 00:20:55,440
types that there are and that's just

516
00:20:58,909 --> 00:20:56,940
going to detail about them now we know

517
00:21:01,190 --> 00:20:58,919
that they get they you know we get them

518
00:21:02,480 --> 00:21:01,200
quickly we and we'll talk about the way

519
00:21:04,250 --> 00:21:02,490
it are discovered in a minute but we

520
00:21:07,580 --> 00:21:04,260
have here according to what Curtis is

521
00:21:11,120 --> 00:21:07,590
showing a type 1 a type 1 B 1 Z and a

522
00:21:13,720 --> 00:21:11,130
type 2 uh who wants to go through some

523
00:21:16,549 --> 00:21:13,730
of these or like type 1a they're very

524
00:21:18,919 --> 00:21:16,559
they're very special kind of supernovae

525
00:21:22,299 --> 00:21:18,929
they they're really useful in a lot of

526
00:21:24,640 --> 00:21:22,309
ways Ryan can you tell us about these

527
00:21:33,980 --> 00:21:24,650
yeah absolutely

528
00:21:36,770 --> 00:21:33,990
so the second best now but no so you

529
00:21:39,200 --> 00:21:36,780
know tech 1a I wrote my my PhD thesis on

530
00:21:41,620 --> 00:21:39,210
type 1a supernovae there's always a

531
00:21:44,919 --> 00:21:41,630
special place in my heart for them and

532
00:21:47,600 --> 00:21:44,929
and they're they are exceptionally

533
00:21:48,409 --> 00:21:47,610
important objects for understanding the

534
00:21:50,990 --> 00:21:48,419
universe as a whole

535
00:21:53,210 --> 00:21:51,000
which you know if you think about this

536
00:21:55,220 --> 00:21:53,220
this tiny star somewhere in some distant

537
00:21:59,090 --> 00:21:55,230
galaxy exploding and that's supposed to

538
00:22:01,580 --> 00:21:59,100

tell us about the entire the entirety of

539
00:22:04,100 --> 00:22:01,590
the universe that's that's important so

540
00:22:05,779 --> 00:22:04,110
the type 1a you know if you're if you're

541
00:22:08,860 --> 00:22:05,789
looking at curtis's little diagram he's

542
00:22:11,450 --> 00:22:08,870
got this very nice final line that

543
00:22:15,020 --> 00:22:11,460
distinguishes from the the type which is

544
00:22:16,100 --> 00:22:15,030
based on the observations with our

545
00:22:19,510 --> 00:22:16,110
physical interpret

546
00:22:22,490 --> 00:22:19,520
and so the type 1a is this thermonuclear

547
00:22:25,280 --> 00:22:22,500
explosion this is what we think is

548
00:22:28,250 --> 00:22:25,290
coming from a white dwarf that explodes

549
00:22:32,299 --> 00:22:28,260
it has a thermonuclear explosion that

550
00:22:35,630 --> 00:22:32,309
will completely shred this star and as a

551
00:22:37,910 --> 00:22:35,640
result generate a bunch of radioactive

552
00:22:41,180 --> 00:22:37,920
material in particular radioactive

553
00:22:44,690 --> 00:22:41,190
nickel and that radioactive nickel

554
00:22:48,710 --> 00:22:44,700
decays first to cobalt and then to iron

555
00:22:51,110 --> 00:22:48,720
which is stable and in that process the

556
00:22:56,560 --> 00:22:51,120
energy that's released on timescales of

557
00:23:00,590 --> 00:22:56,570
days weeks months is injected into the

558
00:23:02,659 --> 00:23:00,600
material that the supernova ejected

559
00:23:06,110 --> 00:23:02,669
outward that's that's the shredded star

560
00:23:09,890 --> 00:23:06,120
and then that material glows and that's

561
00:23:12,230 --> 00:23:09,900
what we see is supernovae now the this

562
00:23:13,909 --> 00:23:12,240
type of supernova because of some of the

563
00:23:16,400 --> 00:23:13,919

intrinsic properties of the explosion

564
00:23:19,730 --> 00:23:16,410
and the star system that they come from

565
00:23:22,070 --> 00:23:19,740
they all seem to be about the same

566
00:23:25,370 --> 00:23:22,080
intrinsic brightness and so we call them

567
00:23:27,470 --> 00:23:25,380
standard candles and in much the same

568
00:23:30,860 --> 00:23:27,480
way that you can when you're driving at

569
00:23:32,780 --> 00:23:30,870
night on on the highway and you see

570
00:23:34,580 --> 00:23:32,790
distant lights from a car you can

571
00:23:36,919 --> 00:23:34,590
estimate how far away that car is by

572
00:23:39,860 --> 00:23:36,929
noticing how bright the the headlights

573
00:23:42,980 --> 00:23:39,870
appeared to you since you know roughly

574
00:23:45,140 --> 00:23:42,990
how bright a headlight should be you can

575
00:23:47,990 --> 00:23:45,150
estimate how far away it is we do the

576
00:23:49,940 --> 00:23:48,000
same thing for supernovae we have some

577
00:23:52,789 --> 00:23:49,950
idea of how intrinsically bright they

578
00:23:56,510 --> 00:23:52,799
are we measure how bright they appear

579
00:23:59,630 --> 00:23:56,520
here and so from those two measurements

580
00:24:01,610 --> 00:23:59,640
we can estimate the distance and yeah

581
00:24:02,930 --> 00:24:01,620
that's a huge point I'm really I really

582
00:24:05,150 --> 00:24:02,940
want to make sure people understand this

583
00:24:07,280 --> 00:24:05,160
because imagine taking a candle folks

584
00:24:08,630 --> 00:24:07,290
right next to your face it's gonna have

585
00:24:10,430 --> 00:24:08,640
a certain brightness you're gonna feel

586
00:24:12,380 --> 00:24:10,440
the heat from it don't burn your hair

587
00:24:13,880 --> 00:24:12,390
but the you it's gonna have a certain

588
00:24:16,190 --> 00:24:13,890

brightness you measure that brightness

589
00:24:18,110 --> 00:24:16,200
of what it is right by your face and you

590
00:24:20,960 --> 00:24:18,120
move it and put it across the room it's

591
00:24:23,390 --> 00:24:20,970
gonna be dimmer how much dimmer it is

592
00:24:25,120 --> 00:24:23,400
will be related to its distance and the

593
00:24:27,710 --> 00:24:25,130
only way you can know how far away it is

594
00:24:29,930 --> 00:24:27,720
isn't you know how bright it is far away

595
00:24:31,460 --> 00:24:29,940
is knowing how bright it

596
00:24:34,639 --> 00:24:31,470
be if it were right in front of your

597
00:24:36,889 --> 00:24:34,649
face and knowing that and that's is is

598
00:24:38,810 --> 00:24:36,899
an important element in measuring how

599
00:24:43,129 --> 00:24:38,820
far away things are and that's why type

600
00:24:45,259 --> 00:24:43,139
1a supernovae are so useful so in

601
00:24:47,450 --> 00:24:45,269
addition to that it's that all of these

602
00:24:49,430 --> 00:24:47,460
candles you know we don't get the

603
00:24:51,200 --> 00:24:49,440
opportunity to move the candle close to

604
00:24:53,690 --> 00:24:51,210
us and see how intrinsically bright it

605
00:24:56,990 --> 00:24:53,700
is right but we know that the you know

606
00:24:58,970 --> 00:24:57,000
that the candle store makes you know all

607
00:25:01,310 --> 00:24:58,980
the same brightness candles and so the

608
00:25:03,560 --> 00:25:01,320
supernova store also happens to make all

609
00:25:06,129 --> 00:25:03,570
the same type 1a supernovae brightnesses

610
00:25:08,240 --> 00:25:06,139
or about that Oh Curtis has a great

611
00:25:11,539 --> 00:25:08,250
graphic up while you're talking go ahead

612
00:25:13,970 --> 00:25:11,549
and so so from that we can measure

613
00:25:15,980 --> 00:25:13,980

distances and because type 1a supernovae

614
00:25:17,810 --> 00:25:15,990
are also in addition to being these

615
00:25:20,210 --> 00:25:17,820
standard candles they're also very very

616
00:25:22,759 --> 00:25:20,220
luminous they're intrinsically bright we

617
00:25:25,779 --> 00:25:22,769
can see them very far away billions of

618
00:25:28,369 --> 00:25:25,789
light years away and and from that

619
00:25:31,669 --> 00:25:28,379
ability to to find things on the other

620
00:25:33,619 --> 00:25:31,679
edge of the universe and then compare

621
00:25:35,960 --> 00:25:33,629
how bright they are to how much the

622
00:25:37,850 --> 00:25:35,970
universe has expanded in the time

623
00:25:39,289 --> 00:25:37,860
between when that supernova explosion

624
00:25:41,119 --> 00:25:39,299
happened because remember billions of

625
00:25:44,029 --> 00:25:41,129
light years away means that it happened

626
00:25:46,789 --> 00:25:44,039
billions of years ago and so you can

627
00:25:48,740 --> 00:25:46,799
compare those to the the amount that the

628
00:25:52,129 --> 00:25:48,750
universe has expanded during that time

629
00:25:54,680 --> 00:25:52,139
to its distance and that that expansion

630
00:25:55,940 --> 00:25:54,690
history right because it's it's it's a

631
00:25:58,960 --> 00:25:55,950
you know you're looking back in time

632
00:26:01,970 --> 00:25:58,970
that expansion history is very much

633
00:26:06,080 --> 00:26:01,980
dependent on the exact content of the

634
00:26:08,240 --> 00:26:06,090
universe and and this this this ability

635
00:26:11,180 --> 00:26:08,250
to measure these distances and compare

636
00:26:14,029 --> 00:26:11,190
them to the the expansion to get the

637
00:26:15,970 --> 00:26:14,039
expansion history led to an assessment

638
00:26:19,639 --> 00:26:15,980

of what the universe was made out of and

639
00:26:22,399 --> 00:26:19,649
about fifteen years ago now or not not

640
00:26:24,649 --> 00:26:22,409
quite 20 years ago now I I

641
00:26:26,930 --> 00:26:24,659
two groups of astronomers use

642
00:26:29,090 --> 00:26:26,940
observations of type 1a supernovae and

643
00:26:31,580 --> 00:26:29,100
they made this assessment they went

644
00:26:34,399 --> 00:26:31,590
through and they said something is kind

645
00:26:38,299 --> 00:26:34,409
of funny here it looks like there's

646
00:26:40,879 --> 00:26:38,309
there's some sort of anti-gravity in the

647
00:26:42,529 --> 00:26:40,889
universe and they and you know they went

648
00:26:43,830 --> 00:26:42,539
back and looked at some of the notes

649
00:26:46,590 --> 00:26:43,840
from Einstein

650
00:26:49,700 --> 00:26:46,600
he had this this idea of something

651
00:26:53,279 --> 00:26:49,710
called a cosmological constant which

652
00:26:57,659 --> 00:26:53,289
produced sort of a cosmic anti-gravity

653
00:26:59,159 --> 00:26:57,669
and the observations appeared to be that

654
00:27:00,510 --> 00:26:59,169
the universe actually had a very large

655
00:27:02,519 --> 00:27:00,520
component of something that we now

656
00:27:04,500 --> 00:27:02,529
called dark energy and that's

657
00:27:07,200 --> 00:27:04,510
essentially just showing our ignorance

658
00:27:08,760 --> 00:27:07,210
we don't really know what it is and

659
00:27:10,399 --> 00:27:08,770
that's that's actually the majority of

660
00:27:13,019 --> 00:27:10,409
the universe it's it's somewhere around

661
00:27:15,419 --> 00:27:13,029
70% to the universe is this dark energy

662
00:27:18,029 --> 00:27:15,429
and we just figured that out you know

663
00:27:20,039 --> 00:27:18,039

you know less than two decades ago and

664
00:27:21,360 --> 00:27:20,049
then type 1a supernovae as you pointed

665
00:27:24,120 --> 00:27:21,370
out were instrumental in that and it was

666
00:27:25,740 --> 00:27:24,130
somebody groups in fact Carolyn we care

667
00:27:27,180 --> 00:27:25,750
we got it we got to do a dark energy

668
00:27:29,610 --> 00:27:27,190
hang out at some point talk about some

669
00:27:31,860 --> 00:27:29,620
of this stuff and so it's really worth

670
00:27:34,110 --> 00:27:31,870
pointing out that that Hubble was

671
00:27:35,730 --> 00:27:34,120
instrumental in this as well yeah and

672
00:27:37,470 --> 00:27:35,740
you know sir Rob should really be giving

673
00:27:41,130 --> 00:27:37,480
this because sir Rob was on one of these

674
00:27:42,210 --> 00:27:41,140
teams that that made this discovery did

675
00:27:43,529 --> 00:27:42,220
you have any comment you want to add to

676
00:27:44,159 --> 00:27:43,539
that you've been holding out on the

677
00:27:50,460 --> 00:27:44,169
Seurat

678
00:27:52,889 --> 00:27:50,470
he's been polite it was a very exciting

679
00:27:54,240 --> 00:27:52,899
time let's put it that way yeah pretty

680
00:27:56,460 --> 00:27:54,250
nasty universe was you know I mean it's

681
00:27:58,320 --> 00:27:56,470
it's really strange because it's you

682
00:28:00,269 --> 00:27:58,330
know using these these white dwarf stars

683
00:28:01,740 --> 00:28:00,279
that we don't when they explode we don't

684
00:28:04,560 --> 00:28:01,750
really understand how I guess we'll get

685
00:28:05,880 --> 00:28:04,570
into that a little bit but we use them

686
00:28:07,139 --> 00:28:05,890
still we saw that they're basically all

687
00:28:09,960 --> 00:28:07,149
the same so we can measure these

688
00:28:11,519 --> 00:28:09,970

distances and we found that the universe

689
00:28:12,870 --> 00:28:11,529
of the galaxies in the universe we knew

690
00:28:14,880 --> 00:28:12,880
they were expanding away from each other

691
00:28:15,960 --> 00:28:14,890
but that they were expanding away faster

692
00:28:17,580 --> 00:28:15,970
and faster that we lived in an

693
00:28:19,350 --> 00:28:17,590
accelerating universe that was a huge

694
00:28:21,029 --> 00:28:19,360
discovery it's like to me through you

695
00:28:22,649 --> 00:28:21,039
know something up in the air and instead

696
00:28:25,169 --> 00:28:22,659
of it coming back down or instead of it

697
00:28:27,169 --> 00:28:25,179
even it's slowing down as it went up it

698
00:28:30,389 --> 00:28:27,179
started going faster and faster yeah

699
00:28:31,860 --> 00:28:30,399
when you and so we call that wide dark

700
00:28:33,419 --> 00:28:31,870
energy but Ryan was exactly right that

701
00:28:35,070 --> 00:28:33,429
you know that's just a name for our

702
00:28:37,049 --> 00:28:35,080
ignorance and so it's you know that

703
00:28:38,789 --> 00:28:37,059
discovery that started from these type

704
00:28:40,710 --> 00:28:38,799
1a supernovae is now at the forefront of

705
00:28:42,570 --> 00:28:40,720
cosmology trying to understand what this

706
00:28:45,029 --> 00:28:42,580
dark energy is that drives our

707
00:28:46,799 --> 00:28:45,039
accelerating Edwards well you raise an

708
00:28:48,810 --> 00:28:46,809
interesting point and actually Ryan

709
00:28:52,409 --> 00:28:48,820
mention as well is that we can't bring

710
00:28:54,899 --> 00:28:52,419
those candles to us and so from the

711
00:28:56,600 --> 00:28:54,909
signature the observations you say oh

712
00:28:59,090 --> 00:28:56,610
this seems like it's a type one

713
00:29:02,180 --> 00:28:59,100

this one seems like a type 1a and then

714
00:29:04,039 --> 00:29:02,190
you said well maybe we don't fully

715
00:29:06,110 --> 00:29:04,049
understand how this explosion occurs

716
00:29:08,690 --> 00:29:06,120
does that make you nervous I mean what

717
00:29:10,669 --> 00:29:08,700
how much do we not know that they're all

718
00:29:14,389 --> 00:29:10,679
the same yeah it doesn't make us nervous

719
00:29:16,310 --> 00:29:14,399
any idea this was all trying to show

720
00:29:18,049 --> 00:29:16,320
that how similar are they and trying to

721
00:29:20,060 --> 00:29:18,059
figure out a way we know that actually

722
00:29:21,919 --> 00:29:20,070
there's a some variation in how bright

723
00:29:23,930 --> 00:29:21,929
these type 1 days are but we can use

724
00:29:26,690 --> 00:29:23,940
clues from the light from the supernova

725
00:29:28,580 --> 00:29:26,700
itself to correct their brightnesses to

726
00:29:30,560 --> 00:29:28,590
make them even more standard sometimes

727
00:29:34,789 --> 00:29:30,570
we call them standardized Abul candles

728
00:29:36,200 --> 00:29:34,799
or calibrated candles so yeah we do have

729
00:29:38,600 --> 00:29:36,210
some ways of checking that you know for

730
00:29:39,919 --> 00:29:38,610
instance sometimes we have two type 1a

731
00:29:42,440 --> 00:29:39,929
supernovae that went off in the same

732
00:29:43,909 --> 00:29:42,450
galaxy and so we can check that do they

733
00:29:45,799 --> 00:29:43,919
end up being the same brightness because

734
00:29:47,480 --> 00:29:45,809
they're the same distance away or more

735
00:29:50,000 --> 00:29:47,490
generally two type 1a supernovae at the

736
00:29:51,440 --> 00:29:50,010
same redshift or when we know one should

737
00:29:53,629 --> 00:29:51,450
be twice as far away as the other

738
00:29:55,970 --> 00:29:53,639

because it has twice the red ship nearby

739
00:29:57,560 --> 00:29:55,980
then we know that the one should be that

740
00:29:59,450 --> 00:29:57,570
one should be four times fainter because

741
00:30:01,220 --> 00:29:59,460
it was twice as far away so we can check

742
00:30:02,840 --> 00:30:01,230
all those things without knowing

743
00:30:04,610 --> 00:30:02,850
anything about the explosion really and

744
00:30:06,110 --> 00:30:04,620
when we do those checks we see how

745
00:30:07,879 --> 00:30:06,120
precise they are and they're remarkably

746
00:30:09,680 --> 00:30:07,889
precise we can met with a good light

747
00:30:12,110 --> 00:30:09,690
karbala type 1a supernova we can measure

748
00:30:13,549 --> 00:30:12,120
its distance to about 10% accuracy or

749
00:30:15,769 --> 00:30:13,559
maybe even a little bit better so the

750
00:30:18,110 --> 00:30:15,779
right light curve is how bright it gets

751
00:30:19,789 --> 00:30:18,120
and then what happens after it starts to

752
00:30:21,230 --> 00:30:19,799
fade that's right it's a trace of how

753
00:30:23,509 --> 00:30:21,240
bright it is over time and it usually

754
00:30:26,029 --> 00:30:23,519
takes you know weeks to months to

755
00:30:27,560 --> 00:30:26,039
brighten and then fade away yeah okay

756
00:30:29,600 --> 00:30:27,570
while we're on the topic of type 1a

757
00:30:42,560 --> 00:30:29,610
supernovae I have a question from bajas

758
00:30:42,570 --> 00:31:04,810
you

759
00:31:11,680 --> 00:31:08,320
who the command a type 1a supernova what

760
00:31:19,150 --> 00:31:11,690
happens to the companion star he wants

761
00:31:21,910 --> 00:31:19,160
to take that do you hear me yes I mean I

762
00:31:24,640 --> 00:31:21,920
guess I can I can mention this so that

763
00:31:27,490 --> 00:31:24,650

the the good question first before you

764
00:31:30,190 --> 00:31:27,500
ask what happened to the companion star

765
00:31:34,780 --> 00:31:30,200
is to understand what the companion star

766
00:31:38,920 --> 00:31:34,790
is and and so for type 1a supernova we

767
00:31:43,120 --> 00:31:38,930
have two very very different scenarios

768
00:31:45,880 --> 00:31:43,130
and and and depending on those two

769
00:31:48,400 --> 00:31:45,890
scenarios then it really changes what

770
00:31:50,890 --> 00:31:48,410
happens to that companion star so I'll

771
00:31:53,740 --> 00:31:50,900
try to generalize this but if I get into

772
00:31:57,130 --> 00:31:53,750
jargon somebody stop me the one way is

773
00:31:59,080 --> 00:31:57,140
if you have two white dwarfs that slowly

774
00:32:00,910 --> 00:31:59,090
come to get when there's something

775
00:32:02,620 --> 00:32:00,920
called gravitational radiation and and

776
00:32:04,920 --> 00:32:02,630
so that these orbits slowly come

777
00:32:07,540 --> 00:32:04,930
together and then eventually they merge

778
00:32:09,640 --> 00:32:07,550
another possibility is that you have a

779
00:32:11,950 --> 00:32:09,650
white dwarf and then something more like

780
00:32:14,800 --> 00:32:11,960
our Sun or a red giant that slowly

781
00:32:16,480 --> 00:32:14,810
transfers mass on to the white dwarf so

782
00:32:17,680 --> 00:32:16,490
in that first scenario where you have

783
00:32:20,140 --> 00:32:17,690
two white dwarfs coming together and

784
00:32:23,140 --> 00:32:20,150
they merge then then that other star is

785
00:32:25,660 --> 00:32:23,150
gone it's it's become you know part of

786
00:32:27,640 --> 00:32:25,670
this you know massive white dwarf for an

787
00:32:30,070 --> 00:32:27,650
instant as the explosion just goes

788
00:32:32,230 --> 00:32:30,080

through it so in that case it's

789
00:32:35,020 --> 00:32:32,240
completely gone just like the the star

790
00:32:38,260 --> 00:32:35,030
that the primary more massive star that

791
00:32:41,020 --> 00:32:38,270
explodes in the other case where there's

792
00:32:44,230 --> 00:32:41,030
something more like our Sun or a big

793
00:32:47,110 --> 00:32:44,240
star I it's a little unclear exactly

794
00:32:50,980 --> 00:32:47,120
what happens you know there was this

795
00:32:53,800 --> 00:32:50,990
giant explosion right nearby and uh and

796
00:32:56,020 --> 00:32:53,810
so something must happen we we have an

797
00:32:57,730 --> 00:32:56,030
understanding of that and there have

798
00:32:59,920 --> 00:32:57,740
been a lot of theoretical modeling to

799
00:33:01,600 --> 00:32:59,930
try to figure this out and so there are

800
00:33:05,740 --> 00:33:01,610
a bunch of things that that we know will

801
00:33:07,510 --> 00:33:05,750
happen so the supernova shock from from

802
00:33:11,260 --> 00:33:07,520
that explosion will go through and

803
00:33:13,270 --> 00:33:11,270
eventually hit that star and some of the

804
00:33:16,630 --> 00:33:13,280
material from the supernova will be

805
00:33:18,610 --> 00:33:16,640
deposited into that star and the

806
00:33:22,540 --> 00:33:18,620
combination of those two things

807
00:33:26,200 --> 00:33:22,550
I will potentially change the how bright

808
00:33:28,420 --> 00:33:26,210
the the star gets and some other aspects

809
00:33:30,549 --> 00:33:28,430
of it but the other thing that is very

810
00:33:32,440 --> 00:33:30,559
important is that you used to have these

811
00:33:34,690 --> 00:33:32,450
two stars in a tight system where they

812
00:33:36,820 --> 00:33:34,700
were going around each other right there

813
00:33:38,320 --> 00:33:36,830

just orbiting each other and then um you

814
00:33:40,690 --> 00:33:38,330
know all of a sudden one is gone and so

815
00:33:42,790 --> 00:33:40,700
what happens to the other one this is

816
00:33:44,080 --> 00:33:42,800
like if you know if you if you're

817
00:33:46,030 --> 00:33:44,090
holding hands with somebody spinning in

818
00:33:49,360 --> 00:33:46,040
a circle and you let go right you just

819
00:33:51,370 --> 00:33:49,370
fly off and so I you know in in this

820
00:33:52,990 --> 00:33:51,380
case when you have these two stars going

821
00:33:54,790 --> 00:33:53,000
around each other one just explodes the

822
00:33:57,340 --> 00:33:54,800
other star is just going to fly off into

823
00:34:01,000 --> 00:33:57,350
space at essentially the the velocity of

824
00:34:03,460 --> 00:34:01,010
the of the orbital speed so so those are

825
00:34:05,290 --> 00:34:03,470
sort of the basics that we know we don't

826
00:34:07,810 --> 00:34:05,300
think for instance that the second star

827
00:34:11,409 --> 00:34:07,820
will explode that doesn't seem to be the

828
00:34:13,300 --> 00:34:11,419
case or something like that I the the

829
00:34:16,450 --> 00:34:13,310
actual changes to the star are probably

830
00:34:18,760 --> 00:34:16,460
minor but some some models have actually

831
00:34:21,820 --> 00:34:18,770
said that they could change in a way

832
00:34:23,530 --> 00:34:21,830
that it would be observable so now I

833
00:34:24,820 --> 00:34:23,540
have a question about that though

834
00:34:27,129 --> 00:34:24,830
because we were we were talking about

835
00:34:30,250 --> 00:34:27,139
earlier about the supernova at 10:54 in

836
00:34:32,080 --> 00:34:30,260
the Crab Nebula and a few months back I

837
00:34:34,270 --> 00:34:32,090
did a show about the Crab Nebula and we

838
00:34:35,619 --> 00:34:34,280

can actually see the Pulsar inside of it

839
00:34:38,730 --> 00:34:35,629
can we go into a little bit of the

840
00:34:41,200 --> 00:34:38,740
Pulsar so here's here's a graphic I made

841
00:34:42,820 --> 00:34:41,210
from observations from Hubble and

842
00:34:45,970 --> 00:34:42,830
Chandra so we can see them the different

843
00:34:47,440 --> 00:34:45,980
wavelengths of what's been observed over

844
00:34:49,869 --> 00:34:47,450
the years and seeing these ripples

845
00:34:51,850 --> 00:34:49,879
through this pulsar wind can we go into

846
00:34:55,060 --> 00:34:51,860
a little bit of that with the supernovae

847
00:34:56,889 --> 00:34:55,070
sure so so the Crab Nebula one because

848
00:34:59,350 --> 00:34:56,899
we see a pulsar there and a pulsar is

849
00:35:02,260 --> 00:34:59,360
just as rapidly very rapidly spinning

850
00:35:04,030 --> 00:35:02,270
neutron star so even more dense than a

851
00:35:05,080 --> 00:35:04,040
white dwarf we talk about white dwarfs

852
00:35:07,630 --> 00:35:05,090
that were roughly the size of the earth

853
00:35:09,460 --> 00:35:07,640
a neutron star is like ten kilometers

854
00:35:12,010 --> 00:35:09,470
wide so the size of a kind of a big city

855
00:35:13,420 --> 00:35:12,020
so you imagine taking like solar masses

856
00:35:15,970 --> 00:35:13,430
of worth of material and really

857
00:35:18,370 --> 00:35:15,980
compressing them in to nuclear densities

858
00:35:19,630 --> 00:35:18,380
and you get a neutron star so in the in

859
00:35:20,980 --> 00:35:19,640
the kind of supernovae that come from

860
00:35:22,810 --> 00:35:20,990
the massive stars

861
00:35:24,910 --> 00:35:22,820
that's what can be left behind the core

862
00:35:26,560 --> 00:35:24,920
collapses all the way down to either a

863
00:35:29,620 --> 00:35:26,570

neutron star like in the Crab Nebula

864
00:35:30,940 --> 00:35:29,630
case or a black hole and so there's some

865
00:35:32,590 --> 00:35:30,950
systems where we might think that

866
00:35:35,890 --> 00:35:32,600
there's a black hole there

867
00:35:37,600 --> 00:35:35,900
a pulsar and so that that's what's gets

868
00:35:39,850 --> 00:35:37,610
left behind the core of the star that

869
00:35:44,680 --> 00:35:39,860
actually exploded is that neutron star

870
00:35:46,120 --> 00:35:44,690
so it's pretty Wow ok so this is a disco

871
00:35:47,410 --> 00:35:46,130
let's go back to the different types

872
00:35:48,700 --> 00:35:47,420
real quick let's finish that up by

873
00:35:53,200 --> 00:35:48,710
Curtis could you put that back up for

874
00:35:54,910 --> 00:35:53,210
that one doc that one type of graphic

875
00:35:56,740 --> 00:35:54,920
you had so we hit that's type one we've

876
00:35:58,870 --> 00:35:56,750
covered that one there are other types

877
00:36:01,900 --> 00:35:58,880
and these were characterized by core

878
00:36:04,030 --> 00:36:01,910
collapse supernova first of all what's a

879
00:36:06,700 --> 00:36:04,040
core collapse supernova Curtis can you

880
00:36:09,160 --> 00:36:06,710
take that one sure so the core collapse

881
00:36:13,150 --> 00:36:09,170
supernovae come from these massive stars

882
00:36:16,570 --> 00:36:13,160
so as Ryan was mentioning before the

883
00:36:18,790 --> 00:36:16,580
high mass stars will explode because the

884
00:36:21,250 --> 00:36:18,800
core will no longer be able to sustain

885
00:36:24,100 --> 00:36:21,260
fusion and eventually it'll collapse

886
00:36:27,760 --> 00:36:24,110
under gravity's just the gravitational

887
00:36:30,250 --> 00:36:27,770
energy and that's what's being put back

888
00:36:32,650 --> 00:36:30,260

into the ejecta so the core collapse

889
00:36:35,650 --> 00:36:32,660
supernovae are aptly named in as much

890
00:36:37,720 --> 00:36:35,660
that their core collapses and then the

891
00:36:40,840 --> 00:36:37,730
outer material the outer envelope it's

892
00:36:43,420 --> 00:36:40,850
that inner core and bounces off and it

893
00:36:44,770 --> 00:36:43,430
explodes as a supernova and so that

894
00:36:46,570 --> 00:36:44,780
pulsar like we were talking about

895
00:36:49,000 --> 00:36:46,580
earlier is what's left behind that

896
00:36:53,770 --> 00:36:49,010
neutron star is what's left behind it's

897
00:36:56,200 --> 00:36:53,780
the core that that of the star that

898
00:36:58,210 --> 00:36:56,210
exploded so the one that what they

899
00:37:00,940 --> 00:36:58,220
produce the Crab Nebula was a core

900
00:37:02,290 --> 00:37:00,950
collapse supernova then yes okay so and

901
00:37:04,780 --> 00:37:02,300
these can be kind of all over the place

902
00:37:06,280 --> 00:37:04,790
as far as brightness right there there's

903
00:37:08,290 --> 00:37:06,290
nowhere to really I mean they're all

904
00:37:10,960 --> 00:37:08,300
variety of Airy brightness is depending

905
00:37:14,230 --> 00:37:10,970
on what how big they are how massive

906
00:37:17,230 --> 00:37:14,240
they are on a variety of things so

907
00:37:20,410 --> 00:37:17,240
everything from how big they are how

908
00:37:21,820 --> 00:37:20,420
many have a binary a companion just like

909
00:37:23,080 --> 00:37:21,830
the white dwarfs even massive stars can

910
00:37:28,350 --> 00:37:23,090
have binary companions and that can

911
00:37:32,710 --> 00:37:31,120
how much their winds might have actually

912
00:37:34,420 --> 00:37:32,720
blown off out of the outer layers the

913
00:37:36,310 --> 00:37:34,430

material can also affect things and so

914
00:37:38,620 --> 00:37:36,320
there's a lot of different variables in

915
00:37:41,020 --> 00:37:38,630
these core collapse supernovae awesome

916
00:37:42,250 --> 00:37:41,030
okay so it's really I mean we're using

917
00:37:44,860 --> 00:37:42,260
kind of like normal words to describe

918
00:37:46,430 --> 00:37:44,870
these really amazing things but every

919
00:37:48,410 --> 00:37:46,440
once in a while I like to remind my

920
00:37:50,029 --> 00:37:48,420
we're talking about the core of this

921
00:37:52,910 --> 00:37:50,039
massive star right before it is about to

922
00:37:55,250 --> 00:37:52,920
collapse is is almost like a white dwarf

923
00:37:58,220 --> 00:37:55,260
at that point it's it's a few solar

924
00:38:00,440 --> 00:37:58,230
masses of material the size of the earth

925
00:38:02,870 --> 00:38:00,450
so that's already mind-boggling and then

926
00:38:06,020 --> 00:38:02,880
in a millisecond it collapses down to

927
00:38:07,549 --> 00:38:06,030
ten kilometers oh I know all that energy

928
00:38:10,069 --> 00:38:07,559
and the rest of the star gets blown

929
00:38:12,250 --> 00:38:10,079
apart I mean it you know that this is

930
00:38:14,089 --> 00:38:12,260
why we like to study these things

931
00:38:15,950 --> 00:38:14,099
astronomy is full of that kind of stuff

932
00:38:17,329 --> 00:38:15,960
that wasn't it I mean we get so so

933
00:38:19,130 --> 00:38:17,339
flippant about certain things

934
00:38:21,349 --> 00:38:19,140
oh yeah a hundred billion stars in a

935
00:38:23,180 --> 00:38:21,359
galaxy 100 billion galaxies the universe

936
00:38:24,859 --> 00:38:23,190
yeah you just were to say things you

937
00:38:27,200 --> 00:38:24,869
know and it's just when you really stop

938
00:38:28,549 --> 00:38:27,210

to think about what this means I can

939
00:38:31,670 --> 00:38:28,559
really be quite humbling Scott what are

940
00:38:34,400 --> 00:38:31,680
you showing this is another one of the

941
00:38:36,740 --> 00:38:34,410
graphics I made for that show or the

942
00:38:39,529 --> 00:38:36,750
neutron star there it's one the mass of

943
00:38:43,099 --> 00:38:39,539
one point four Suns in a twenty

944
00:38:44,450 --> 00:38:43,109
kilometer diameter yeah all of you know

945
00:38:45,920 --> 00:38:44,460
and it's gonna be a little hard to see

946
00:38:47,299 --> 00:38:45,930
here on and the hang-up because it is a

947
00:38:48,620 --> 00:38:47,309
really quick image so I'm gonna be

948
00:38:50,569 --> 00:38:48,630
putting it into the event page and

949
00:38:53,210 --> 00:38:50,579
tweeting it out here in a second but

950
00:38:56,089 --> 00:38:53,220
it's really crazy to think about a

951
00:38:58,430 --> 00:38:56,099
twenty kilometer diameter but the same

952
00:39:00,589 --> 00:38:58,440
you know it's more massive than our Sun

953
00:39:03,859 --> 00:39:00,599
almost one and a half of the masses of

954
00:39:07,839 --> 00:39:03,869
our Sun in that small small volume

955
00:39:26,120 --> 00:39:23,269
someday she would be the light so

956
00:39:27,890 --> 00:39:26,130
that'll speed up your community oh god

957
00:39:29,210 --> 00:39:27,900
we sure need that but they're

958
00:39:34,099 --> 00:39:29,220
spaghettification that might be

959
00:39:36,349 --> 00:39:34,109
happening okay what I want to cover a

960
00:39:37,640 --> 00:39:36,359
couple more basics on on supernovae they

961
00:39:43,039 --> 00:39:37,650
don't want to talk into some specifics

962
00:39:48,890 --> 00:39:43,049
of specific Hubble observations so we

963
00:39:50,240 --> 00:39:48,900

know that that supernovae are what

964
00:39:52,430 --> 00:39:50,250
they're what we they had different types

965
00:39:55,010 --> 00:39:52,440
or different brightnesses how often do

966
00:39:59,269 --> 00:39:55,020
these things occur how common is a

967
00:40:00,110 --> 00:39:59,279
supernova explosion Jen when how often

968
00:40:02,990 --> 00:40:00,120
is okay

969
00:40:05,870 --> 00:40:03,000
to simplify the question in our galaxy

970
00:40:09,350 --> 00:40:05,880
the Milky Way how many times will we see

971
00:40:11,660 --> 00:40:09,360
an explosion like this you just made it

972
00:40:18,590 --> 00:40:11,670
harder well I'm either harder yeah bison

973
00:40:20,900 --> 00:40:18,600
all right okay in the Union so the

974
00:40:24,680 --> 00:40:20,910
number I remember is in the visible

975
00:40:27,670 --> 00:40:24,690
universe there's one every second in our

976
00:40:29,900 --> 00:40:27,680
galaxy there's roughly one every century

977
00:40:32,810 --> 00:40:29,910
off but that doesn't mean that we see

978
00:40:34,490 --> 00:40:32,820
them all because of just our location in

979
00:40:37,160 --> 00:40:34,500
the galaxy where in the disk of the

980
00:40:39,740 --> 00:40:37,170
galaxy most of the stars are in the disk

981
00:40:41,750 --> 00:40:39,750
as well and there's a lot of dust in in

982
00:40:43,160 --> 00:40:41,760
the disk and so most of the time we're

983
00:40:46,250 --> 00:40:43,170
looking through that dust that dust

984
00:40:48,920 --> 00:40:46,260
makes it hard to see other things and so

985
00:40:51,650 --> 00:40:48,930
most of the time we we won't see one so

986
00:40:54,530 --> 00:40:51,660
the last the last supernova that has

987
00:40:57,530 --> 00:40:54,540
definitively been seen by people on

988
00:41:02,300 --> 00:40:57,540

earth from our Milky Way was over 400

989
00:41:06,620 --> 00:41:02,310
years ago to give an idea Kepler in 1604

990
00:41:09,920 --> 00:41:06,630
yeah and uh and and so even though we're

991
00:41:13,000 --> 00:41:09,930
do well you could say that but then

992
00:41:16,670 --> 00:41:13,010
there was a very nearby supernova in

993
00:41:18,920 --> 00:41:16,680
1987 that occurred in a dwarf galaxy

994
00:41:22,370 --> 00:41:18,930
that orbits the Milky Way so it's right

995
00:41:24,100 --> 00:41:22,380
in our backyard and so that happened you

996
00:41:27,050 --> 00:41:24,110
know

997
00:41:29,900 --> 00:41:27,060
it depends on it depends on how you do

998
00:41:32,570 --> 00:41:29,910
your accounting no no I am that doesn't

999
00:41:34,700 --> 00:41:32,580
count the Ryans yeah because uh I mean

1000
00:41:36,800 --> 00:41:34,710
I'm Adam 1604 that was the one Kepler

1001
00:41:39,350 --> 00:41:36,810
observed his supernova actually just 32

1002
00:41:41,300 --> 00:41:39,360
years before in 1572 there was another

1003
00:41:43,220 --> 00:41:41,310
Milky Way supernova and so the people

1004
00:41:44,540 --> 00:41:43,230
who lived then you know if they had the

1005
00:41:45,680 --> 00:41:44,550
Hubble Space Telescope you know they

1006
00:41:48,410 --> 00:41:45,690
would have learned all this amazing

1007
00:41:49,700 --> 00:41:48,420
stuff about those bogarted all on thirty

1008
00:41:53,840 --> 00:41:49,710
years in our galaxy

1009
00:41:57,130 --> 00:41:53,850
okay I wanna stick up a little bit for

1010
00:41:59,390 --> 00:41:57,140
1987a because we have lots of HST

1011
00:42:02,780 --> 00:41:59,400
observations we've actually been able to

1012
00:42:07,350 --> 00:42:02,790
see it change over time which has given

1013
00:42:11,140 --> 00:42:07,360

us some interesting information about

1014
00:42:13,390 --> 00:42:11,150
surroundings and honestly from from my

1015
00:42:16,060 --> 00:42:13,400
perspective I would rather see something

1016
00:42:18,880 --> 00:42:16,070
in Andromeda than in the Milky Way

1017
00:42:21,580 --> 00:42:18,890
because in the Milky Way odds are it

1018
00:42:23,200 --> 00:42:21,590
will be in the disc it will have a lot

1019
00:42:25,450 --> 00:42:23,210
of problems actually figuring out what's

1020
00:42:28,660 --> 00:42:25,460
going on whereas Andromeda are the next

1021
00:42:30,190 --> 00:42:28,670
big galaxies it's one of those things

1022
00:42:32,800 --> 00:42:30,200
where you can you can probably make very

1023
00:42:34,090 --> 00:42:32,810
precise measurements of it and it's

1024
00:42:36,250 --> 00:42:34,100
still close enough where you can get all

1025
00:42:38,950 --> 00:42:36,260
this extra data that we're really hoping

1026
00:42:40,540 --> 00:42:38,960
to get about the it's a funny irony

1027
00:42:43,200 --> 00:42:40,550
actually you know because we have big

1028
00:42:45,760 --> 00:42:43,210
telescopes and they're expensive

1029
00:42:47,350 --> 00:42:45,770
instruments but you know obviously I

1030
00:42:48,850 --> 00:42:47,360
think totally worth it because of all

1031
00:42:50,770 --> 00:42:48,860
this stuff that we learn about them so

1032
00:42:52,900 --> 00:42:50,780
we put our best instruments our best

1033
00:42:54,670 --> 00:42:52,910
cameras or best spectrographs on those

1034
00:42:56,530 --> 00:42:54,680
biggest telescopes and if we have a

1035
00:43:02,530 --> 00:42:56,540
supernova like the star Betelgeuse for

1036
00:43:04,660 --> 00:43:02,540
example it's do they float right you

1037
00:43:06,040 --> 00:43:04,670
wouldn't be any of our great telescopes

1038
00:43:07,510 --> 00:43:06,050

it would be too bright for those tools

1039
00:43:09,430 --> 00:43:07,520
that's right and we'd all have to break

1040
00:43:12,340 --> 00:43:09,440
out our celeste ron's and our you know

1041
00:43:15,340 --> 00:43:12,350
our binoculars and our eyeballs and try

1042
00:43:16,900 --> 00:43:15,350
and learn that way so I'm glad you

1043
00:43:18,820 --> 00:43:16,910
brought that up I'm glad you brought

1044
00:43:22,050 --> 00:43:18,830
that up because my next question before

1045
00:43:25,540 --> 00:43:22,060
I start going to some other comments is

1046
00:43:27,640 --> 00:43:25,550
are we in danger is earth or is this as

1047
00:43:29,740 --> 00:43:27,650
our solar system or Betelgeuse goes

1048
00:43:32,920 --> 00:43:29,750
what's gonna do we have to worry about

1049
00:43:34,480 --> 00:43:32,930
supernovae probably not so I packed at

1050
00:43:38,050 --> 00:43:34,490
Rutgers a couple years ago I taught a

1051
00:43:43,480 --> 00:43:38,060
seminar called death from the skies by

1052
00:43:45,700 --> 00:43:43,490
somebody too as the textbook for that

1053
00:43:48,310 --> 00:43:45,710
class for that seminar and for a

1054
00:43:50,410 --> 00:43:48,320
supernova it turns out we're not any of

1055
00:43:51,370 --> 00:43:50,420
the stars nearby they're massive enough

1056
00:43:54,040 --> 00:43:51,380
that are likely to become a supernova

1057
00:43:56,050 --> 00:43:54,050
are not near enough to really affect us

1058
00:43:57,970 --> 00:43:56,060
a supernova would have to be pretty

1059
00:44:02,080 --> 00:43:57,980
close within just a few light years to

1060
00:44:03,520 --> 00:44:02,090
pose a serious problem so so right now

1061
00:44:04,840 --> 00:44:03,530
we're not in danger however there is

1062
00:44:06,850 --> 00:44:04,850
evidence on the earth that there have

1063
00:44:08,680 --> 00:44:06,860

been nearby supernovae where the earth

1064
00:44:10,960 --> 00:44:08,690
and the Sun were just near a massive

1065
00:44:12,970 --> 00:44:10,970
star at a previous time in the history

1066
00:44:15,370 --> 00:44:12,980
of our orbit around the galaxy where

1067
00:44:16,540 --> 00:44:15,380
there that did happen so you know we

1068
00:44:18,730 --> 00:44:16,550
don't have to worry right now but maybe

1069
00:44:20,020 --> 00:44:18,740
look so what keeps me up at night or

1070
00:44:20,770 --> 00:44:20,030
gamma-ray bursts but that's another

1071
00:44:22,630 --> 00:44:20,780
topic I

1072
00:44:23,920 --> 00:44:22,640
I would like to we should have it we

1073
00:44:27,490 --> 00:44:23,930
should have a hangout all that to Carol

1074
00:44:32,050 --> 00:44:27,500
a death in the skies or something we can

1075
00:44:33,640 --> 00:44:32,060
die okay so Charles Bell is asking and

1076
00:44:35,680 --> 00:44:33,650
this is a good segue into the next thing

1077
00:44:37,750 --> 00:44:35,690
I want to talk about on the Google+

1078
00:44:39,910 --> 00:44:37,760
event page he's asking is there a

1079
00:44:42,550 --> 00:44:39,920
pipeline process to check new images

1080
00:44:44,950 --> 00:44:42,560
taken by Hubble for supernovae in any

1081
00:44:46,390 --> 00:44:44,960
galaxies in the field of view and let me

1082
00:44:49,180 --> 00:44:46,400
ask that question another way how does

1083
00:44:51,340 --> 00:44:49,190
Hubble discover supernovas because the

1084
00:44:53,320 --> 00:44:51,350
second question is have any supernovae

1085
00:44:57,400 --> 00:44:53,330
been discovered by Hubble the short

1086
00:44:59,170 --> 00:44:57,410
answer is yes but maybe maybe Carol you

1087
00:45:01,630 --> 00:44:59,180
make you comment on that a little bit

1088
00:45:04,680 --> 00:45:01,640

some of the the ways in which Hubble

1089
00:45:08,290 --> 00:45:04,690
look at the sky that to find supernovae

1090
00:45:10,600 --> 00:45:08,300
well also I think also Saab can probably

1091
00:45:14,110 --> 00:45:10,610
address this as well but there is a

1092
00:45:16,240 --> 00:45:14,120
campaign now ever since you know this

1093
00:45:19,000 --> 00:45:16,250
early work on the expansion of the

1094
00:45:23,140 --> 00:45:19,010
universe where there's a number of

1095
00:45:26,290 --> 00:45:23,150
things if there are if somebody else

1096
00:45:29,350 --> 00:45:26,300
discovers a supernova the there are

1097
00:45:33,700 --> 00:45:29,360
observers that can ask the director to

1098
00:45:35,650 --> 00:45:33,710
immediately look at that object and take

1099
00:45:38,820 --> 00:45:35,660
a series of observations with the Hubble

1100
00:45:43,720 --> 00:45:38,830
Space Telescope there's also a campaign

1101
00:45:48,340 --> 00:45:43,730
for observations that are taken by other

1102
00:45:50,290 --> 00:45:48,350
observers at distant galaxies to comb

1103
00:45:54,040 --> 00:45:50,300
through that data to look for so

1104
00:45:55,450 --> 00:45:54,050
supernovae so there's not there are

1105
00:45:57,700 --> 00:45:55,460
other telescopes that look for

1106
00:46:00,340 --> 00:45:57,710
supernovae in particular and asteroids

1107
00:46:02,620 --> 00:46:00,350
and all kinds of things Hubble does not

1108
00:46:04,240 --> 00:46:02,630
have a campaign specifically where you

1109
00:46:06,370 --> 00:46:04,250
just point in the sky and hope there's a

1110
00:46:08,890 --> 00:46:06,380
supernova but observations that are

1111
00:46:12,760 --> 00:46:08,900
being used for something else are then

1112
00:46:15,340 --> 00:46:12,770
examined to see if there are supernovae

1113
00:46:16,990 --> 00:46:15,350

that events and if they find them fast

1114
00:46:18,790 --> 00:46:17,000
enough they can go back and observe

1115
00:46:19,630 --> 00:46:18,800
either with Hubble or another

1116
00:46:21,880 --> 00:46:19,640
observatory

1117
00:46:24,070 --> 00:46:21,890
so do you wanna elaborate on that little

1118
00:46:25,900 --> 00:46:24,080
sure yeah so what we often call these

1119
00:46:27,760 --> 00:46:25,910
supernovae searches piggybacking on

1120
00:46:30,400 --> 00:46:27,770
other people's search so you might have

1121
00:46:32,380 --> 00:46:30,410
seen these iconic images from Hubble

1122
00:46:34,570 --> 00:46:32,390
like the Deep Field and the Ultra Deep

1123
00:46:36,520 --> 00:46:34,580
Field and the way they take those images

1124
00:46:38,440 --> 00:46:36,530
is that Hubble has to point at one small

1125
00:46:41,890 --> 00:46:38,450
patch of the sky for a long time for

1126
00:46:43,810 --> 00:46:41,900
hours or days and so you could do that

1127
00:46:45,430 --> 00:46:43,820
you could just point it at for a few

1128
00:46:47,110 --> 00:46:45,440
days at the same patch on the sky and

1129
00:46:49,330 --> 00:46:47,120
then just say okay here's my great image

1130
00:46:51,640 --> 00:46:49,340
but what the supernova folks likes to do

1131
00:46:53,950 --> 00:46:51,650
is say hey why don't you slow down a

1132
00:46:56,050 --> 00:46:53,960
little bit and spread that time out over

1133
00:46:57,910 --> 00:46:56,060
a few months and so instead of observing

1134
00:46:59,890 --> 00:46:57,920
all at once take one image and then come

1135
00:47:02,620 --> 00:46:59,900
back later a month later and then again

1136
00:47:03,580 --> 00:47:02,630
another month in the end after you know

1137
00:47:05,260 --> 00:47:03,590
a certain amount of time you'll have

1138
00:47:06,940 --> 00:47:05,270

your full data set that you can add

1139
00:47:08,710 --> 00:47:06,950
together and make your beautiful Deep

1140
00:47:10,660 --> 00:47:08,720
Field but in the meantime we'll be able

1141
00:47:12,970 --> 00:47:10,670
to look at each month and say hey was

1142
00:47:14,980 --> 00:47:12,980
there a new object there a new supernova

1143
00:47:16,720 --> 00:47:14,990
that went off in in between and so

1144
00:47:19,330 --> 00:47:16,730
that's what we do we piggyback on these

1145
00:47:22,420 --> 00:47:19,340
big surveys like candles and clash and

1146
00:47:24,760 --> 00:47:22,430
now the frontier fields to use Hubble to

1147
00:47:27,310 --> 00:47:24,770
find supernovae and the reason we want

1148
00:47:29,140 --> 00:47:27,320
Hubble to find two novae yes many people

1149
00:47:30,520 --> 00:47:29,150
can find them from the ground and even

1150
00:47:31,540 --> 00:47:30,530
amateur astronomers find supernovae

1151
00:47:34,630 --> 00:47:31,550
which is I think a really fascinating

1152
00:47:36,040 --> 00:47:34,640
part of this science topic but Hubble is

1153
00:47:38,290 --> 00:47:36,050
the only thing that can find a really

1154
00:47:39,940 --> 00:47:38,300
really distant one the ones that are ten

1155
00:47:41,410 --> 00:47:39,950
billion light-years away and we want to

1156
00:47:43,330 --> 00:47:41,420
know what the universe was like all the

1157
00:47:44,800 --> 00:47:43,340
way back then and so Hubble is really

1158
00:47:47,110 --> 00:47:44,810
key at finding the most distant

1159
00:47:49,480 --> 00:47:47,120
supernovae and we love to use public to

1160
00:47:52,000 --> 00:47:49,490
find mine so I was gonna comment because

1161
00:47:54,690 --> 00:47:52,010
I think Tony you mentioned it before at

1162
00:47:58,090 --> 00:47:54,700
some point that in the frontier fields

1163
00:48:00,730 --> 00:47:58,100

which are deep observations that are

1164
00:48:03,280 --> 00:48:00,740
being taken over a three-year period of

1165
00:48:07,120 --> 00:48:03,290
six clusters and we've talked about that

1166
00:48:10,290 --> 00:48:07,130
on hangouts before and just as sirup

1167
00:48:14,710 --> 00:48:10,300
said the the observations are

1168
00:48:17,890 --> 00:48:14,720
interspersed and and also you don't want

1169
00:48:19,900 --> 00:48:17,900
to dominate the just with one program so

1170
00:48:21,730 --> 00:48:19,910
other programs are fitting in between

1171
00:48:23,490 --> 00:48:21,740
this and very early in the frontier

1172
00:48:26,830 --> 00:48:23,500
fields one of the first frontier fields

1173
00:48:29,230 --> 00:48:26,840
observed there was a supernova and it is

1174
00:48:31,210 --> 00:48:29,240
likely over a three-year period that

1175
00:48:34,090 --> 00:48:31,220
those fields because those observations

1176
00:48:36,580 --> 00:48:34,100
are spread out for so long that other

1177
00:48:38,050 --> 00:48:36,590
supernovae by the way I wanted to

1178
00:48:39,760 --> 00:48:38,060
mention other things of the question

1179
00:48:41,590 --> 00:48:39,770
asked whether there was a pipeline to do

1180
00:48:43,480 --> 00:48:41,600
this and there is a pipeline on that

1181
00:48:46,390 --> 00:48:43,490
pipelines damage Curtis McCauley

1182
00:48:47,620 --> 00:48:46,400
among others Steve Rodman so we have

1183
00:48:49,210 --> 00:48:47,630
people and pretty

1184
00:48:51,190 --> 00:48:49,220
driving student with me at Rutgers and

1185
00:48:53,080 --> 00:48:51,200
when he was here he helped develop

1186
00:48:54,880 --> 00:48:53,090
pipeline that's now being used in the

1187
00:48:56,860 --> 00:48:54,890
frontier fields when the Hubble takes

1188
00:48:59,680 --> 00:48:56,870

you do you have to take that data match

1189
00:49:01,540 --> 00:48:59,690
it up data subtract it to the images to

1190
00:49:03,940 --> 00:49:01,550
look for anything new and often there's

1191
00:49:05,440 --> 00:49:03,950
a lot of stuff from you know a cosmic

1192
00:49:07,150 --> 00:49:05,450
ray that was one image that's not the

1193
00:49:08,380 --> 00:49:07,160
other and so Curtis developed some of

1194
00:49:10,480 --> 00:49:08,390
the tools some of the software that we

1195
00:49:16,510 --> 00:49:10,490
use to find what are the real new things

1196
00:49:18,220 --> 00:49:16,520
that real news producer right now I'm

1197
00:49:27,840 --> 00:49:18,230
telling Tony you put on headphones -

1198
00:49:41,920 --> 00:49:30,970
ok you can speak now well not until I

1199
00:49:44,590 --> 00:49:41,930
change it no it's worse what you just

1200
00:49:47,890 --> 00:49:44,600
did man you're on yeah your microphones

1201
00:49:53,920 --> 00:49:47,900
down but the echo is gone so which I

1202
00:49:59,190 --> 00:49:53,930
kind of like yeah no you're very faint

1203
00:50:02,710 --> 00:50:01,540
speak into the microphone Tony I'm

1204
00:50:04,570 --> 00:50:02,720
speaking into the microphone

1205
00:50:09,550 --> 00:50:04,580
no the microphone is far away from your

1206
00:50:12,360 --> 00:50:09,560
mouth is this better yeah yeah okay all

1207
00:50:15,730 --> 00:50:12,370
right now sorry about that folks

1208
00:50:17,470 --> 00:50:15,740
feedback okay

1209
00:50:18,820 --> 00:50:17,480
so they I don't know if this is going to

1210
00:50:20,770 --> 00:50:18,830
work or not but alais not if you could

1211
00:50:23,140 --> 00:50:20,780
put up the frontier fields thing on the

1212
00:50:24,370 --> 00:50:23,150
little new showcase app that they have

1213
00:50:26,230 --> 00:50:24,380

hopefully this will be something that

1214
00:50:29,560 --> 00:50:26,240
will illustrate what we were just

1215
00:50:31,960 --> 00:50:29,570
talking about it with the question of

1216
00:50:34,900 --> 00:50:31,970
have has Hubble discovered any

1217
00:50:36,400 --> 00:50:34,910
supernovae the answer is of course it's

1218
00:50:38,080 --> 00:50:36,410
discovered many and in fact with the

1219
00:50:39,490 --> 00:50:38,090
frontier fields initiative one of the

1220
00:50:41,470 --> 00:50:39,500
things that does and one of the ways in

1221
00:50:43,870 --> 00:50:41,480
which supernovae are discovered is you

1222
00:50:45,100 --> 00:50:43,880
look at a patch of sky you take some

1223
00:50:46,870 --> 00:50:45,110
images and then you go back and you look

1224
00:50:48,130 --> 00:50:46,880
at it again and if there's any new stars

1225
00:50:49,930 --> 00:50:48,140
you'll know that hey there's you know

1226
00:50:51,640 --> 00:50:49,940
there must be that's a supernova going

1227
00:50:54,340 --> 00:50:51,650
there it's one of the triggers for for

1228
00:50:55,690 --> 00:50:54,350
having seen one and I think frontier

1229
00:50:57,190 --> 00:50:55,700
fields was under it was going for just a

1230
00:51:00,850 --> 00:50:57,200
few weeks and it had already discovered

1231
00:51:01,450 --> 00:51:00,860
its first its first supernova so this

1232
00:51:03,730 --> 00:51:01,460
one wasn't

1233
00:51:07,060 --> 00:51:03,740
right or anything but it was it was a

1234
00:51:08,890 --> 00:51:07,070
discovery Curtis I may be off track here

1235
00:51:10,570 --> 00:51:08,900
with this question and I'm if I if I'm

1236
00:51:14,890 --> 00:51:10,580
asking the wrong person please let me

1237
00:51:16,359 --> 00:51:14,900
know but your organization LLC ODT do

1238
00:51:19,510 --> 00:51:16,369

you guys have any supernova surveys

1239
00:51:21,250 --> 00:51:19,520
ground-based surveys there so LC OTT is

1240
00:51:25,060 --> 00:51:21,260
actually designed to be more of a

1241
00:51:25,540 --> 00:51:25,070
follow-up machine kind of what I'm sorry

1242
00:51:29,470 --> 00:51:25,550
Carol

1243
00:51:31,390 --> 00:51:29,480
carol was saying earlier about where

1244
00:51:32,890 --> 00:51:31,400
somebody else discovers a supernova and

1245
00:51:37,089 --> 00:51:32,900
then we can simply turn one of our

1246
00:51:39,700 --> 00:51:37,099
telescopes and start observing it okay

1247
00:51:41,170 --> 00:51:39,710
all right so I there are surveys though

1248
00:51:43,089 --> 00:51:41,180
that look at large areas of the sky

1249
00:51:45,460 --> 00:51:43,099
multiple times a night or multiple times

1250
00:51:51,849 --> 00:51:45,470
over the course of some period to find

1251
00:51:54,640 --> 00:51:51,859
these these supernovae you know in big

1252
00:51:57,339 --> 00:51:54,650
areas so okay so I want to move on to

1253
00:51:59,470 --> 00:51:57,349
some of the particulars of some of your

1254
00:52:00,490 --> 00:51:59,480
work with Hubble so Rob you have

1255
00:52:03,160 --> 00:52:00,500
mentioned something that you had done

1256
00:52:04,210 --> 00:52:03,170
something with a zombie star with using

1257
00:52:05,620 --> 00:52:04,220
Hubble do you wanna talk about that a

1258
00:52:07,150 --> 00:52:05,630
little bit that's right yeah so actually

1259
00:52:10,050 --> 00:52:07,160
all three of us Ryan and Curtis and I

1260
00:52:12,520 --> 00:52:10,060
were working on this kind of object and

1261
00:52:13,780 --> 00:52:12,530
you know we talked about how type 1a

1262
00:52:16,599 --> 00:52:13,790
supernovae are so important for

1263
00:52:18,190 --> 00:52:16,609

cosmology and yet Ryan said well here

1264
00:52:20,140 --> 00:52:18,200
are two possible ways they might explode

1265
00:52:22,480 --> 00:52:20,150
one was with two white dwarfs that

1266
00:52:24,940 --> 00:52:22,490
merged together to explode and one was

1267
00:52:26,829 --> 00:52:24,950
material from a normal star being dumped

1268
00:52:28,780 --> 00:52:26,839
onto a white dwarf who exploded and so

1269
00:52:30,460 --> 00:52:28,790
you would think that hey that's a big

1270
00:52:34,030 --> 00:52:30,470
difference whether you have to like you

1271
00:52:35,620 --> 00:52:34,040
know like worth merging or not and yet

1272
00:52:37,540 --> 00:52:35,630
you these are the same objects that you

1273
00:52:39,160 --> 00:52:37,550
use to measure the accelerating universe

1274
00:52:40,300 --> 00:52:39,170
and you know carol was asking doesn't

1275
00:52:42,190 --> 00:52:40,310
that make you uncomfortable that you

1276
00:52:45,440 --> 00:52:42,200
don't really know exactly how they

1277
00:52:49,370 --> 00:52:47,270
but in some art from the cosmology

1278
00:52:51,170 --> 00:52:49,380
application of these type 1 days is what

1279
00:52:53,030 --> 00:52:51,180
are they and so for a while we've been

1280
00:52:55,940 --> 00:52:53,040
trying to attack this question with you

1281
00:52:57,500 --> 00:52:55,950
know lots of people have have and one of

1282
00:52:58,880 --> 00:52:57,510
the things we like to do because I don't

1283
00:53:01,220 --> 00:52:58,890
know maybe we're kind of weird people

1284
00:53:03,500 --> 00:53:01,230
but we like to look at the weirdo type

1285
00:53:05,030 --> 00:53:03,510
one A's so every so often we get a type

1286
00:53:07,609 --> 00:53:05,040
1a or something that looks like a type

1287
00:53:09,230 --> 00:53:07,619
1a but isn't the same luminosity it's

1288
00:53:10,849 --> 00:53:09,240

somewhat different so there are a few

1289
00:53:12,050 --> 00:53:10,859
that are a little too bright and then

1290
00:53:13,190 --> 00:53:12,060
there are a few that are too faint and

1291
00:53:15,349 --> 00:53:13,200
we've been studying the ones that are

1292
00:53:17,690 --> 00:53:15,359
too faint and we still think that these

1293
00:53:18,770 --> 00:53:17,700
are the these morph explosions Ryan came

1294
00:53:22,220 --> 00:53:18,780
up with a great name for them we call

1295
00:53:25,280 --> 00:53:22,230
them type 1a X supernovae and the X is

1296
00:53:27,200 --> 00:53:25,290
mysterious and it also harkens back to

1297
00:53:29,599 --> 00:53:27,210
the first one that we identified of this

1298
00:53:33,380 --> 00:53:29,609
class which was a supernova called 2002

1299
00:53:35,120 --> 00:53:33,390
CX and so the idea is if we can study

1300
00:53:37,220 --> 00:53:35,130
these weirdos and what makes them

1301
00:53:39,050 --> 00:53:37,230
different than normal type 1a s we might

1302
00:53:40,790 --> 00:53:39,060
understand how all the weirdos come from

1303
00:53:42,410 --> 00:53:40,800
this kind of star and all the normals

1304
00:53:43,520 --> 00:53:42,420
come from two white dwarfs merging or

1305
00:53:45,380 --> 00:53:43,530
whatever the case may be

1306
00:53:46,430 --> 00:53:45,390
and so we've been studying these weirdos

1307
00:53:48,109 --> 00:53:46,440
and one of the things we would like to

1308
00:53:51,530 --> 00:53:48,119
do with the weirdos there was one in

1309
00:53:53,270 --> 00:53:51,540
2012 called 2012 Z and it was a great

1310
00:53:55,970 --> 00:53:53,280
coincidence that that galaxy that it

1311
00:54:00,410 --> 00:53:55,980
went off in in NGC 1309 I don't know if

1312
00:54:03,559 --> 00:54:00,420
we have a picture of that I think for an

1313
00:54:05,599 --> 00:54:03,569

actor of 2012 Z so what we did is we

1314
00:54:07,880 --> 00:54:05,609
there was already and this is one of the

1315
00:54:10,160 --> 00:54:07,890
great things about Hubble is that

1316
00:54:12,230 --> 00:54:10,170
there's the Hubble archive so any

1317
00:54:14,510 --> 00:54:12,240
astronomer after the Hubble data has

1318
00:54:16,370 --> 00:54:14,520
been taken after a period of time easily

1319
00:54:18,349 --> 00:54:16,380
a year or so that did it becomes public

1320
00:54:21,440 --> 00:54:18,359
to the whole world and anyone can go

1321
00:54:24,109 --> 00:54:21,450
look to see what is in that data and so

1322
00:54:26,809 --> 00:54:24,119
this supernova went off in 2012 scary

1323
00:54:34,280 --> 00:54:26,819
isn't it now okay great and so that's

1324
00:54:35,930 --> 00:54:34,290
actually this is 2014 J yeah but so we

1325
00:54:38,420 --> 00:54:35,940
had the supernova in 2012 that went off

1326
00:54:41,000 --> 00:54:38,430
in this galaxy NGC 1309 this nice

1327
00:54:43,450 --> 00:54:41,010
beautiful spiral galaxy and there's a

1328
00:54:47,390 --> 00:54:43,460
little too inset boxes on the on the

1329
00:54:49,609 --> 00:54:47,400
link I sent anyway and what happened is

1330
00:54:51,950 --> 00:54:49,619
that one of our colleagues have actually

1331
00:54:56,240 --> 00:54:51,960
taken lots of images of that galaxy to

1332
00:54:57,349 --> 00:54:56,250
study the aftermath of 2002 so in the

1333
00:54:59,330 --> 00:54:57,359
Hubble archive there were these great

1334
00:55:01,400 --> 00:54:59,340
images of this

1335
00:55:03,710 --> 00:55:01,410
this galaxy and what we could do is we

1336
00:55:05,990 --> 00:55:03,720
could go back and look to see what was

1337
00:55:08,090 --> 00:55:06,000
at the position there it is so there's

1338
00:55:12,230 --> 00:55:08,100

that beautiful galaxy on the left and

1339
00:55:14,210 --> 00:55:12,240
then on the right so if we zoom in on

1340
00:55:18,650 --> 00:55:14,220
the location of the new supernova in

1341
00:55:20,690 --> 00:55:18,660
2012 on the right what we found and

1342
00:55:22,700 --> 00:55:20,700
actually this was a really June work of

1343
00:55:24,170 --> 00:55:22,710
Curtis who took all that old data and

1344
00:55:27,110 --> 00:55:24,180
combined them together in a really

1345
00:55:29,870 --> 00:55:27,120
optimal way to make all the the stars as

1346
00:55:31,490 --> 00:55:29,880
sharp as possible so on the lower right

1347
00:55:33,410 --> 00:55:31,500
you see the position of the supernovae

1348
00:55:34,910 --> 00:55:33,420
which went off in 2012 the image is

1349
00:55:36,710 --> 00:55:34,920
actually from 2013 when the supernova

1350
00:55:39,290 --> 00:55:36,720
was faint enough that it we could get a

1351
00:55:41,630 --> 00:55:39,300
good image with Hubble and then on the

1352
00:55:43,850 --> 00:55:41,640
upper part is the data from 2005 and

1353
00:55:46,550 --> 00:55:43,860
2006 before the supernova went off and

1354
00:55:48,770 --> 00:55:46,560
what we found for this weirdo white

1355
00:55:50,360 --> 00:55:48,780
dwarf supernova this type 1 ax that we

1356
00:55:52,610 --> 00:55:50,370
call is that there was actually

1357
00:55:54,860 --> 00:55:52,620
something there where that arrow s1

1358
00:55:56,720 --> 00:55:54,870
points to a little blue smudge now that

1359
00:55:58,970 --> 00:55:56,730
probably doesn't look like much to the

1360
00:56:01,670 --> 00:55:58,980
viewers but when Curtis showed me and

1361
00:56:03,350 --> 00:56:01,680
Ryan that we were ecstatic you know I'll

1362
00:56:04,610 --> 00:56:03,360
let them tell you about what their field

1363
00:56:07,010 --> 00:56:04,620

their feelings were when they when we

1364
00:56:09,200 --> 00:56:07,020
made this discovery but the idea that

1365
00:56:11,480 --> 00:56:09,210
for a white dwarf supernova where people

1366
00:56:13,250 --> 00:56:11,490
have been looking to see a progenitor

1367
00:56:15,590 --> 00:56:13,260
the star that exploded before a white

1368
00:56:17,690 --> 00:56:15,600
dwarf supernova for a long time and they

1369
00:56:19,460 --> 00:56:17,700
never did and so that actually led a lot

1370
00:56:21,140 --> 00:56:19,470
of people to think that most of these

1371
00:56:22,880 --> 00:56:21,150
white dwarf supernovae came from - white

1372
00:56:24,170 --> 00:56:22,890
dwarfs merging where the white dwarfs

1373
00:56:26,180 --> 00:56:24,180
would be too faint to see that's why we

1374
00:56:29,140 --> 00:56:26,190
never saw them but in this case in this

1375
00:56:31,370 --> 00:56:29,150
weirdo case we did see something and so

1376
00:56:33,590 --> 00:56:31,380
we wrote a whole paper on it it was in

1377
00:56:36,560 --> 00:56:33,600
nature and we did a little press release

1378
00:56:39,500 --> 00:56:36,570
and I don't know who was maybe Carol had

1379
00:56:41,060 --> 00:56:39,510
a hand in it but someone knows so we

1380
00:56:43,100 --> 00:56:41,070
talked about well this is this dead star

1381
00:56:44,630 --> 00:56:43,110
this white dwarf but it sort of got

1382
00:56:46,670 --> 00:56:44,640
resurrected when it got this material

1383
00:56:49,250 --> 00:56:46,680
transferred onto it from this blue

1384
00:56:50,660 --> 00:56:49,260
companion that we're seeing and so well

1385
00:56:52,520 --> 00:56:50,670
that sounds like a zombie you know and

1386
00:56:54,200 --> 00:56:52,530
so we called it a zombie star and we you

1387
00:56:55,550 --> 00:56:54,210
know we went with that and the news

1388
00:56:57,200 --> 00:56:55,560

loved that so there were lots of news

1389
00:56:58,850 --> 00:56:57,210
articles about this zombie star that we

1390
00:57:00,230 --> 00:56:58,860
discovered and really the important

1391
00:57:01,820 --> 00:57:00,240
thing is that you know is the first time

1392
00:57:03,500 --> 00:57:01,830
for a white dwarf supernova we got to

1393
00:57:06,410 --> 00:57:03,510
see what was there before and we

1394
00:57:08,690 --> 00:57:06,420
actually saw something great so we are

1395
00:57:12,500 --> 00:57:08,700
almost out of time boys has gone by fast

1396
00:57:14,450 --> 00:57:12,510
I had a lot more point out that

1397
00:57:16,880 --> 00:57:14,460
ah nummy that has not changed since the

1398
00:57:19,340 --> 00:57:16,890
first person who called him or herself

1399
00:57:23,540 --> 00:57:19,350
an astronomer looked up and named a star

1400
00:57:27,800 --> 00:57:23,550
is that we name things any which way we

1401
00:57:31,220 --> 00:57:27,810
want and that's why we have lots of

1402
00:57:33,260 --> 00:57:31,230
weird names of objects you know I always

1403
00:57:35,120 --> 00:57:33,270
thought it was the zombie star because

1404
00:57:37,640 --> 00:57:35,130
I'm seeing the supernova remnants and

1405
00:57:40,220 --> 00:57:37,650
they kind of look like brains and I just

1406
00:57:43,220 --> 00:57:40,230
you know like oh I see why they're

1407
00:57:44,720 --> 00:57:43,230
zombies stars I see what you want to see

1408
00:57:45,920 --> 00:57:44,730
in them I think they're like Rorschach

1409
00:57:49,190 --> 00:57:45,930
tests so maybe it's telling me more

1410
00:57:50,330 --> 00:57:49,200
about you and well honestly I think they

1411
00:57:53,450 --> 00:57:50,340
look like Metroid's

1412
00:57:57,290 --> 00:57:53,460
that's like the old-school gamer in me

1413
00:57:58,850 --> 00:57:57,300

oh my goodness okay so let's get to one

1414
00:58:01,040 --> 00:57:58,860
question before we have to go this is

1415
00:58:03,560 --> 00:58:01,050
from the Q&A app Shane Taylor is asking

1416
00:58:06,590 --> 00:58:03,570
may the variation of brightness between

1417
00:58:09,140 --> 00:58:06,600
type 1a supernovae be the difference

1418
00:58:11,810 --> 00:58:09,150
between what type of stars caused it a

1419
00:58:13,190 --> 00:58:11,820
white dwarf type 1a supernovae throws

1420
00:58:14,810 --> 00:58:13,200
off a specific type of brightness

1421
00:58:16,820 --> 00:58:14,820
compared to a type 1a triggered

1422
00:58:17,290 --> 00:58:16,830
supernova by a merging of two neutron

1423
00:58:20,090 --> 00:58:17,300
stars

1424
00:58:22,840 --> 00:58:20,100
so let me parse that a little bit may

1425
00:58:24,770 --> 00:58:22,850
the variation brightness between the

1426
00:58:26,030 --> 00:58:24,780
first of all is there much of a

1427
00:58:27,860 --> 00:58:26,040
variation in brightness between the

1428
00:58:29,060 --> 00:58:27,870
different types of type 1a supernovae

1429
00:58:32,180 --> 00:58:29,070
they're pretty much all the same that's

1430
00:58:34,640 --> 00:58:32,190
the point right so I'll handle this

1431
00:58:36,770 --> 00:58:34,650
because I've done a little bit of work

1432
00:58:38,900 --> 00:58:36,780
on this so first of all we for one age

1433
00:58:40,520 --> 00:58:38,910
we don't know what creates them we don't

1434
00:58:42,110 --> 00:58:40,530
know if it's the merger of two white

1435
00:58:43,840 --> 00:58:42,120
dwarfs the question you know says the

1436
00:58:46,760 --> 00:58:43,850
neutron stars but we know it's not that

1437
00:58:48,200 --> 00:58:46,770
it could be the merger of two white

1438
00:58:50,360 --> 00:58:48,210

dwarfs or it could be this white dwarf

1439
00:58:52,730 --> 00:58:50,370
that gets material from another star and

1440
00:58:55,970 --> 00:58:52,740
we don't know it could be one or the

1441
00:58:58,790 --> 00:58:55,980
other or some combination of both the

1442
00:59:01,730 --> 00:58:58,800
one the one observation that we have

1443
00:59:04,220 --> 00:59:01,740
that show some difference between

1444
00:59:08,660 --> 00:59:04,230
progenitor systems and this is not in

1445
00:59:11,870 --> 00:59:08,670
terms of of the the companion star as

1446
00:59:14,240 --> 00:59:11,880
necessarily but we're able to detect if

1447
00:59:17,180 --> 00:59:14,250
there's outflowing material in the

1448
00:59:19,070 --> 00:59:17,190
circumstellar system so we can figure

1449
00:59:21,770 --> 00:59:19,080
out if there is some sort of wind coming

1450
00:59:24,260 --> 00:59:21,780
off of either an accretion disk or or

1451
00:59:26,420 --> 00:59:24,270
the the companion star or something like

1452
00:59:28,910 --> 00:59:26,430
that and we can say that some

1453
00:59:31,520 --> 00:59:28,920
I seem to have that and some do not some

1454
00:59:34,790 --> 00:59:31,530
you know stars that end up becoming a

1455
00:59:36,710 --> 00:59:34,800
type 1a supernovae and if you if you

1456
00:59:39,020 --> 00:59:36,720
separate those two classes those that

1457
00:59:41,270 --> 00:59:39,030
have these outflows and those that don't

1458
00:59:42,680 --> 00:59:41,280
there are luminosities we still have not

1459
00:59:46,849 --> 00:59:42,690
been able to say that they're different

1460
00:59:48,650 --> 00:59:46,859
but we can say that the velocity at

1461
00:59:51,049 --> 00:59:48,660
which you know the material is expelled

1462
00:59:53,900 --> 00:59:51,059
is slightly different for those two

1463
00:59:56,569 --> 00:59:53,910

systems but that's the only observation

1464
00:59:59,569 --> 00:59:56,579
yet that we have for the progenitor

1465
01:00:02,210 --> 00:59:59,579
systems themselves now we have made

1466
01:00:04,790 --> 01:00:02,220
other comparisons at sort of like bulk

1467
01:00:06,200 --> 01:00:04,800
properties of the galaxy so we know for

1468
01:00:09,260 --> 01:00:06,210
instance type 1a supernovae that come

1469
01:00:11,569 --> 01:00:09,270
from big elliptical galaxies they tend

1470
01:00:14,359 --> 01:00:11,579
to be fainter intrinsically than the

1471
01:00:16,040 --> 01:00:14,369
ones that come from spiral galaxies but

1472
01:00:17,809 --> 01:00:16,050
we correct for that because of this this

1473
01:00:19,490 --> 01:00:17,819
light curve thing that's rob was talking

1474
01:00:20,690 --> 01:00:19,500
about before and if you make that

1475
01:00:23,480 --> 01:00:20,700
correction then there's there's no

1476
01:00:25,400 --> 01:00:23,490
difference that it's really it's a great

1477
01:00:27,079 --> 01:00:25,410
question because that's exactly what you

1478
01:00:29,299 --> 01:00:27,089
would think the different progenitor is

1479
01:00:30,980 --> 01:00:29,309
should lead to different kinds of

1480
01:00:32,720 --> 01:00:30,990
supernovae even slightly different maybe

1481
01:00:35,329 --> 01:00:32,730
the two white dwarfs would be slightly

1482
01:00:36,950 --> 01:00:35,339
brighter or fainter and so the the

1483
01:00:38,690 --> 01:00:36,960
question that's that the the question

1484
01:00:40,730 --> 01:00:38,700
are asked I mean that's exactly the kind

1485
01:00:42,349 --> 01:00:40,740
of hypotheses that a scientists we kind

1486
01:00:44,059 --> 01:00:42,359
of formulated and we're like okay let's

1487
01:00:45,349 --> 01:00:44,069
try and look and let's say let's see if

1488
01:00:46,760 --> 01:00:45,359

we can tell the difference in the

1489
01:00:48,620 --> 01:00:46,770
brightness if they come from this kind

1490
01:00:50,089 --> 01:00:48,630
of galaxies or if they're really young

1491
01:00:52,010 --> 01:00:50,099
or they're really old or something like

1492
01:00:54,380 --> 01:00:52,020
that and the really surprising thing is

1493
01:00:57,200 --> 01:00:54,390
that the 1a s are very similar there is

1494
01:01:00,460 --> 01:00:57,210
some range but it it seems me somehow

1495
01:01:03,799 --> 01:01:00,470
nature no matter what the inputs were a

1496
01:01:05,120 --> 01:01:03,809
writer used a great analogy and Nadia

1497
01:01:07,220 --> 01:01:05,130
Drake in an article that she wrote about

1498
01:01:09,440 --> 01:01:07,230
type 1a supernovae you have different

1499
01:01:11,210 --> 01:01:09,450
ingredients in different recipes and yet

1500
01:01:13,190 --> 01:01:11,220
the final product turns out the same so

1501
01:01:14,539 --> 01:01:13,200
that somehow nature does that we're

1502
01:01:16,490 --> 01:01:14,549
trying to figure out why that is oh

1503
01:01:17,930 --> 01:01:16,500
that's a great that's a great analogy

1504
01:01:19,640 --> 01:01:17,940
okay well thank you should me for that

1505
01:01:21,319 --> 01:01:19,650
great question I'm afraid we're out of

1506
01:01:23,510 --> 01:01:21,329
time folks we're gonna have to stop here

1507
01:01:26,359 --> 01:01:23,520
I want to thank thank you guys sir Rob

1508
01:01:27,799 --> 01:01:26,369
and and Ryan and Curtis this has been an

1509
01:01:29,390 --> 01:01:27,809
awesome hangout thank you for taking

1510
01:01:31,880 --> 01:01:29,400
time out to talk about super novae with

1511
01:01:34,640 --> 01:01:31,890
us and next week folks we'll be back on

1512
01:01:38,329 --> 01:01:34,650
our regular time on Thursday 3:00 p.m.

1513
01:01:39,990 --> 01:01:38,339

Eastern 7:00 p.m. Greenwich Time where

1514
01:01:42,960 --> 01:01:40,000
we will be talking about

1515
01:01:45,360 --> 01:01:42,970
the plumes of Europa if you may remember

1516
01:01:48,000 --> 01:01:45,370
recently that we have did a press

1517
01:01:49,770 --> 01:01:48,010
release where there were some RIT some

1518
01:01:52,350 --> 01:01:49,780
research done looking at Europa plumes

1519
01:01:54,030 --> 01:01:52,360
and so we'll have the scientists on hand

1520
01:01:55,590 --> 01:01:54,040
to discuss that so we'll hope you'll

1521
01:01:56,880 --> 01:01:55,600
join us I'll have the event up by

1522
01:01:59,340 --> 01:01:56,890
tomorrow so you guys can let us know

1523
01:02:01,620 --> 01:01:59,350
you're coming on behalf of Carroll and

1524
01:02:04,950 --> 01:02:01,630
coalition Scott Lewis my name is Tony