

1  
00:00:06,370 --> 00:00:12,019  
hello everybody and welcome to our

2  
00:00:08,839 --> 00:00:13,820  
latest Hubble hangout we are back from

3  
00:00:12,019 --> 00:00:16,339  
our two-week summer break thank you guys

4  
00:00:13,820 --> 00:00:18,379  
for watching today my name is Tony

5  
00:00:16,339 --> 00:00:20,030  
Darnell I work at the Space Telescope

6  
00:00:18,379 --> 00:00:21,589  
Science Institute and today we have a

7  
00:00:20,030 --> 00:00:24,050  
really great hangout planned for you

8  
00:00:21,589 --> 00:00:26,960  
today today we have a hangout plan today

9  
00:00:24,050 --> 00:00:30,050  
okay so I'm gonna be redundant also but

10  
00:00:26,960 --> 00:00:47,210  
today we're gonna find it today all

11  
00:00:30,050 --> 00:00:49,429  
right what sounds like you plan my group

12  
00:00:47,210 --> 00:00:52,460  
there so today's topic we're going to be

13  
00:00:49,429 --> 00:00:54,530  
talking about super novae what they are

14  
00:00:52,460 --> 00:00:56,390  
the basics of them and some of the

15  
00:00:54,530 --> 00:00:57,969  
latest research with supernova

16  
00:00:56,390 --> 00:01:00,009  
explosions we have a panel of

17  
00:00:57,969 --> 00:01:02,808  
astronomers here to help us with that

18  
00:01:00,009 --> 00:01:05,420  
joining me this week as they always do

19  
00:01:02,808 --> 00:01:06,590  
is dr. Carol Christians from she's from

20  
00:01:05,420 --> 00:01:09,799  
the Space Telescope Science Institute

21  
00:01:06,590 --> 00:01:11,149  
also Oh welcome Carol Jeff did you have

22  
00:01:09,799 --> 00:01:14,539  
a good vacation you have a good time off

23  
00:01:11,149 --> 00:01:17,118  
absolutely yeah okay also is Scott Lewis

24  
00:01:14,539 --> 00:01:19,009  
from know the cosmos comm and he's are

25  
00:01:17,118 --> 00:01:20,569  
all over the place in the internet doing

26  
00:01:19,009 --> 00:01:22,340  
all kinds of awesome things welcome back

27  
00:01:20,569 --> 00:01:25,519  
Scott it's good to see you again yes

28  
00:01:22,340 --> 00:01:30,649  
good to see you too I've missed you yes

29

00:01:25,519 --> 00:01:33,289  
I've missed ya I haven't missed you guys

30  
00:01:30,649 --> 00:01:41,118  
at all I've missed you Carol I don't

31  
00:01:33,289 --> 00:01:44,689  
care what you say okay this is something

32  
00:01:41,118 --> 00:01:46,310  
rusty okay so today I said today we are

33  
00:01:44,688 --> 00:01:49,339  
going to be talking about supernovae and

34  
00:01:46,310 --> 00:01:52,368  
we want you to interact with us and the

35  
00:01:49,340 --> 00:01:55,039  
way you can do that is Hubble hangout

36  
00:01:52,368 --> 00:01:57,649  
hashtag on Twitter the Q&A app on

37  
00:01:55,039 --> 00:01:58,939  
YouTube and Google+ and the Google+

38  
00:01:57,649 --> 00:02:00,918  
event page we hope you'll leave us

39  
00:01:58,938 --> 00:02:03,218  
questions and comments also we're

40  
00:02:00,918 --> 00:02:07,489  
noticing that there is a new thing on

41  
00:02:03,218 --> 00:02:09,649  
the Google Hangouts on air interface

42  
00:02:07,489 --> 00:02:12,289  
there's a little pair of hands where you

43  
00:02:09,649 --> 00:02:13,039

can I guess do something applaud or

44

00:02:12,289 --> 00:02:13,568  
something like that

45

00:02:13,039 --> 00:02:17,530  
so let

46

00:02:13,568 --> 00:02:18,968  
feel free to use that and whatever that

47

00:02:17,530 --> 00:02:20,079  
thing does I don't know what it is yet

48

00:02:18,968 --> 00:02:21,519  
we also have we're going to be

49

00:02:20,079 --> 00:02:23,200  
experimenting with this thing called a

50

00:02:21,519 --> 00:02:24,700  
showcase where we're gonna try and show

51

00:02:23,199 --> 00:02:26,530  
you some new things during the Hangout

52

00:02:24,699 --> 00:02:29,158  
as well all of that will be a little bit

53

00:02:26,530 --> 00:02:32,859  
experimental so let's get on with it

54

00:02:29,158 --> 00:02:34,388  
supernovae explosions that's what we're

55

00:02:32,859 --> 00:02:38,859  
here to talk about today and they are

56

00:02:34,389 --> 00:02:40,989  
among some of the brightest events that

57

00:02:38,859 --> 00:02:44,590  
occur in the universe they are these

58  
00:02:40,989 --> 00:02:48,400  
they are these deaths of of stars that

59  
00:02:44,590 --> 00:02:51,519  
are for a brief period of time are can

60  
00:02:48,400 --> 00:02:53,438  
outshine an entire galaxy in fact they

61  
00:02:51,519 --> 00:02:56,709  
will put out more energy in a few weeks

62  
00:02:53,438 --> 00:02:58,718  
in a few months then the Sun will in its

63  
00:02:56,709 --> 00:03:02,259  
entire lifetime so these are very

64  
00:02:58,718 --> 00:03:03,579  
energetic events they occur at a rate

65  
00:03:02,259 --> 00:03:04,840  
which we will talk about a little bit

66  
00:03:03,579 --> 00:03:06,609  
later on I don't want to give away too

67  
00:03:04,840 --> 00:03:08,530  
many punch lines because I just want to

68  
00:03:06,609 --> 00:03:10,090  
give some background on the kinds of

69  
00:03:08,530 --> 00:03:13,449  
things we're talking about not all stars

70  
00:03:10,090 --> 00:03:15,188  
blow up some only certain certain ones

71  
00:03:13,449 --> 00:03:17,169  
do there's also different types of stars

72  
00:03:15,188 --> 00:03:19,568  
so that explosions that can happen and

73  
00:03:17,169 --> 00:03:22,180  
to talk about all of these details today

74  
00:03:19,568 --> 00:03:25,539  
we have a panel of expert astronomers

75  
00:03:22,180 --> 00:03:28,629  
and let me introduce them first from

76  
00:03:25,539 --> 00:03:31,959  
Rutgers an astronomer so rube sir Rob is

77  
00:03:28,628 --> 00:03:34,840  
it Jah Jah yeah not great I love that

78  
00:03:31,959 --> 00:03:36,459  
when it'll screw it up too bad he's an

79  
00:03:34,840 --> 00:03:38,799  
astronomer at Rutgers University also

80  
00:03:36,459 --> 00:03:41,408  
with us is Ryan Foley a professor at the

81  
00:03:38,799 --> 00:03:43,209  
at the of astronomy at the University of

82  
00:03:41,408 --> 00:03:44,828  
Illinois a place RI was spent a couple

83  
00:03:43,209 --> 00:03:47,650  
of years so it's nice to see somebody

84  
00:03:44,829 --> 00:03:51,340  
from U of I there also Curtis McCauley

85  
00:03:47,650 --> 00:03:53,889  
he's a postdoc at you just say where are

86

00:03:51,340 --> 00:03:57,280  
you from Curtis so I'm at LC OGT and

87  
00:03:53,889 --> 00:03:59,620  
UCSB so LC OTT is Las Cumbres Global

88  
00:03:57,280 --> 00:04:02,408  
Telescope and UCSB is University of

89  
00:03:59,620 --> 00:04:05,019  
California Santa Barbara ah okay thank

90  
00:04:02,408 --> 00:04:07,568  
you and welcome to all three of you so

91  
00:04:05,019 --> 00:04:10,150  
let me let me start with you I'm sort of

92  
00:04:07,568 --> 00:04:12,878  
Saurabh can you give us some background

93  
00:04:10,150 --> 00:04:16,269  
some basics on what supernova explosions

94  
00:04:12,878 --> 00:04:18,370  
are so that's great and supernovae are

95  
00:04:16,269 --> 00:04:20,978  
exploding stars so we have this word and

96  
00:04:18,370 --> 00:04:23,590  
even the word sometimes trips people up

97  
00:04:20,978 --> 00:04:25,959  
so we usually say one is a supernova

98  
00:04:23,589 --> 00:04:27,158  
with just an a at the end and if you

99  
00:04:25,959 --> 00:04:27,370  
were talking about more than one then

100  
00:04:27,158 --> 00:04:30,399

that

101

00:04:27,370 --> 00:04:33,490

super novae with AE it's just funny a

102

00:04:30,399 --> 00:04:35,679

Greek Latin hybrid thing so the New York

103

00:04:33,490 --> 00:04:37,210

Times calls them supernovas so feel free

104

00:04:35,680 --> 00:04:45,069

to call them supernovas as well that's

105

00:04:37,209 --> 00:04:47,609

totally fine no no super oh yeah you

106

00:04:45,069 --> 00:04:49,990

have to say super no because it's fine

107

00:04:47,610 --> 00:04:51,100

yeah so they're exploiting stars and I

108

00:04:49,990 --> 00:04:52,900

as you said right at the end of their

109

00:04:51,100 --> 00:04:55,330

lives some stars explode and I guess

110

00:04:52,899 --> 00:04:56,560

we'll get into which ones do and there

111

00:04:55,329 --> 00:04:57,939

are few of many different kinds and

112

00:04:56,560 --> 00:04:59,709

we're trying to figure out what kind of

113

00:04:57,939 --> 00:05:01,209

stars turn into what kind of explosions

114

00:04:59,709 --> 00:05:03,219

and the Hubble Space Telescope has



115  
00:05:01,209 --> 00:05:04,899  
helped a lot with that now we know a lot

116  
00:05:03,220 --> 00:05:06,970  
about supernovae already I mean we've

117  
00:05:04,899 --> 00:05:08,829  
been seeing them for thousands of years

118  
00:05:06,970 --> 00:05:10,840  
I think the first recorded supernova as

119  
00:05:08,829 --> 00:05:15,430  
I was we're always taught in astronomy

120  
00:05:10,839 --> 00:05:17,079  
101 was in 1054 right yeah there may be

121  
00:05:15,430 --> 00:05:18,930  
some records even before that but yeah

122  
00:05:17,079 --> 00:05:22,029  
1054 we have a pretty well-documented

123  
00:05:18,930 --> 00:05:24,788  
one and you can go back to look at

124  
00:05:22,029 --> 00:05:28,679  
records that people kept in China and

125  
00:05:24,788 --> 00:05:31,839  
Japan saying on in fact on July 4th 1054

126  
00:05:28,680 --> 00:05:34,449  
before the fireworks absolutely but

127  
00:05:31,839 --> 00:05:36,638  
there were some celestial fireworks that

128  
00:05:34,449 --> 00:05:42,490  
day I think that's a plug for murica

129  
00:05:36,639 --> 00:05:45,668  
though it was a premonition of great

130  
00:05:42,490 --> 00:05:47,110  
things to come in in America yeah and

131  
00:05:45,668 --> 00:05:49,209  
then actually what the amazing thing is

132  
00:05:47,110 --> 00:05:50,530  
now we can go back and you know they the

133  
00:05:49,209 --> 00:05:52,478  
astronomers at that time kept really

134  
00:05:50,529 --> 00:05:54,848  
good records of where that new star

135  
00:05:52,478 --> 00:05:57,159  
occurred and we can go back and look at

136  
00:05:54,848 --> 00:05:58,598  
that right now and when we go there we

137  
00:05:57,160 --> 00:06:00,130  
point for instance Hubble there there

138  
00:05:58,598 --> 00:06:02,620  
are beautiful images of the Crab Nebula

139  
00:06:00,129 --> 00:06:05,829  
so we can see now the Stars ground up

140  
00:06:02,620 --> 00:06:07,990  
now that exploded in 1054 so you know

141  
00:06:05,829 --> 00:06:09,189  
almost a thousand years later we can see

142  
00:06:07,990 --> 00:06:11,470  
what it looks like so it's pretty

143

00:06:09,189 --> 00:06:12,788  
amazing and this this would have looked

144  
00:06:11,470 --> 00:06:14,320  
this would have been something they

145  
00:06:12,788 --> 00:06:15,969  
people could have well obviously they

146  
00:06:14,319 --> 00:06:18,189  
did look up and see it in their own

147  
00:06:15,970 --> 00:06:19,690  
night sky and I believe they're saying

148  
00:06:18,189 --> 00:06:21,490  
it was bright enough to be seen during

149  
00:06:19,689 --> 00:06:22,810  
the day is that correct yeah I think

150  
00:06:21,490 --> 00:06:25,418  
that is true yeah and it's in the

151  
00:06:22,810 --> 00:06:27,639  
constellation of Taurus I think and you

152  
00:06:25,418 --> 00:06:29,139  
know usually at that time new stars in

153  
00:06:27,639 --> 00:06:31,090  
the skies but that was usually bad for

154  
00:06:29,139 --> 00:06:33,819  
the king or the Emperor or whatever it

155  
00:06:31,089 --> 00:06:35,829  
was a usually a bad omen but for us in

156  
00:06:33,819 --> 00:06:38,649  
astronomy reluctancy stars explode and

157  
00:06:35,829 --> 00:06:40,550

see what they're made of and even enrich

158

00:06:38,649 --> 00:06:42,439  
the universe with all that stuff

159

00:06:40,550 --> 00:06:45,650  
comments have that same reputation so

160

00:06:42,439 --> 00:06:50,029  
all right so not but not the supernova

161

00:06:45,649 --> 00:06:52,310  
explosions are a way in which a star

162

00:06:50,029 --> 00:06:53,839  
can die now most people know and if you

163

00:06:52,310 --> 00:06:55,910  
don't I'll remind you that stars burn

164

00:06:53,839 --> 00:06:59,810  
through a nuclear fusion they have these

165

00:06:55,910 --> 00:07:02,660  
these us is that make let them shine and

166

00:06:59,810 --> 00:07:04,819  
it's very complicated and and in and

167

00:07:02,660 --> 00:07:06,890  
they generate a lot lot of energy but

168

00:07:04,819 --> 00:07:09,980  
stars also come in different shapes and

169

00:07:06,889 --> 00:07:12,829  
sizes and colors and temperatures what

170

00:07:09,980 --> 00:07:14,840  
kind of stars in their life this way and

171

00:07:12,829 --> 00:07:18,370  
let me let me get the Ryan in on this

172  
00:07:14,839 --> 00:07:25,579  
how about can you take that one for me

173  
00:07:18,370 --> 00:07:28,220  
well you're muted I think sorry so what

174  
00:07:25,579 --> 00:07:31,069  
so first of all what we think is just

175  
00:07:28,220 --> 00:07:33,380  
about every star that's particularly

176  
00:07:31,069 --> 00:07:35,990  
massive say you know something that's

177  
00:07:33,379 --> 00:07:38,839  
ten times as massive as our Sun or even

178  
00:07:35,990 --> 00:07:41,240  
more will probably explode as a

179  
00:07:38,839 --> 00:07:43,669  
supernova there's there's some actually

180  
00:07:41,240 --> 00:07:45,889  
really interesting theoretical idea is

181  
00:07:43,670 --> 00:07:47,840  
that maybe they'll some subset will

182  
00:07:45,889 --> 00:07:49,669  
collapse directly to a black hole and

183  
00:07:47,839 --> 00:07:51,769  
not have a supernova at the end of its

184  
00:07:49,670 --> 00:07:53,629  
life but the vast majority should and

185  
00:07:51,769 --> 00:07:57,949  
we've seen this because we've been able

186  
00:07:53,629 --> 00:07:59,389  
to detect stars after they occur we have

187  
00:07:57,949 --> 00:08:01,550  
seen the explosion we've gone back at

188  
00:07:59,389 --> 00:08:03,589  
our old images and seeing the stars

189  
00:08:01,550 --> 00:08:05,629  
there and then we see the Superdome and

190  
00:08:03,589 --> 00:08:07,489  
then we look much later and we see that

191  
00:08:05,629 --> 00:08:11,569  
the star is gone so we know that that's

192  
00:08:07,490 --> 00:08:14,449  
happened then there are less massive

193  
00:08:11,569 --> 00:08:16,699  
stars that eventually after going

194  
00:08:14,449 --> 00:08:19,329  
through this full process of living

195  
00:08:16,699 --> 00:08:21,680  
their lives kind of like our Sun and

196  
00:08:19,329 --> 00:08:23,149  
going on to another stage called like

197  
00:08:21,680 --> 00:08:25,129  
the red the red giant stage where

198  
00:08:23,149 --> 00:08:27,819  
they're really big and and puffy and

199  
00:08:25,129 --> 00:08:29,930  
then eventually becoming a white dwarf a

200

00:08:27,819 --> 00:08:32,929  
white dwarf is essentially just the

201  
00:08:29,930 --> 00:08:35,419  
center of that star after all of the

202  
00:08:32,929 --> 00:08:38,209  
nuclear fusion has has happened and it's

203  
00:08:35,419 --> 00:08:40,819  
just slowly cooling down but a subset of

204  
00:08:38,210 --> 00:08:43,910  
white dwarfs that are in systems with

205  
00:08:40,820 --> 00:08:47,330  
another star very nearby and gain some

206  
00:08:43,909 --> 00:08:49,730  
mass from that other star and eventually

207  
00:08:47,330 --> 00:08:51,560  
get to conditions inside the star where

208  
00:08:49,730 --> 00:08:53,720  
you can restart nuclear fusion

209  
00:08:51,559 --> 00:08:53,929  
but you restarted in a way where the new

210  
00:08:53,720 --> 00:08:56,930  
clue

211  
00:08:53,929 --> 00:09:01,149  
is a runaway it causes a major explosion

212  
00:08:56,929 --> 00:09:03,709  
and that will result in a supernova so

213  
00:09:01,149 --> 00:09:06,649  
those are the two main categories of

214  
00:09:03,710 --> 00:09:08,570

stellar explosions and there and the big

215

00:09:06,649 --> 00:09:10,399

lint the big factor here to determine is

216

00:09:08,570 --> 00:09:12,170

whether a star explodes or not is it

217

00:09:10,399 --> 00:09:14,509

sighs I think you said ten times the

218

00:09:12,169 --> 00:09:16,669

mass of our Sun right yeah so so you

219

00:09:14,509 --> 00:09:18,799

know there's that one of the very

220

00:09:16,669 --> 00:09:21,289

important areas of research right now is

221

00:09:18,799 --> 00:09:23,479

determining the exact minimum maths the

222

00:09:21,289 --> 00:09:26,360

smallest star can be and explode in that

223

00:09:23,480 --> 00:09:28,700

way and and most people kind of are

224

00:09:26,360 --> 00:09:32,149

pinning it around eight times the mass

225

00:09:28,700 --> 00:09:34,580

of the Sun but you know 10 we we will

226

00:09:32,149 --> 00:09:37,190

see that thing explode for the most part

227

00:09:34,580 --> 00:09:40,940

but yeah and it's the it's it's actually

228

00:09:37,190 --> 00:09:44,089

the the mass of the core near the end of



229  
00:09:40,940 --> 00:09:47,060  
its life not necessarily how much how

230  
00:09:44,089 --> 00:09:48,529  
big the star is when when it's more like

231  
00:09:47,059 --> 00:09:50,569  
the the Sun when it's burning hydrogen

232  
00:09:48,528 --> 00:09:53,570  
into helium it's really at the end that

233  
00:09:50,570 --> 00:09:55,490  
matters I but that's the technicality

234  
00:09:53,570 --> 00:09:57,950  
for the most part we can you know if you

235  
00:09:55,490 --> 00:09:59,870  
starts off at ten times it'll explode

236  
00:09:57,950 --> 00:10:01,278  
okay so one thing I want to clarify is

237  
00:09:59,870 --> 00:10:03,620  
you said that there are two ways they

238  
00:10:01,278 --> 00:10:07,039  
can be triggered and one of them had to

239  
00:10:03,620 --> 00:10:09,289  
do with the white dwarf being re somehow

240  
00:10:07,039 --> 00:10:11,870  
reignited or somehow fusion processes

241  
00:10:09,289 --> 00:10:14,179  
being restarted again and that exploded

242  
00:10:11,870 --> 00:10:16,850  
right so yeah is there two explosions

243  
00:10:14,179 --> 00:10:18,859  
then well no so these are two separate

244  
00:10:16,850 --> 00:10:22,430  
events completely so one are the very

245  
00:10:18,860 --> 00:10:25,220  
massive stars that they look they they

246  
00:10:22,429 --> 00:10:27,489  
blow up because eventually what what

247  
00:10:25,220 --> 00:10:29,509  
ends up happening is that the the

248  
00:10:27,490 --> 00:10:32,690  
diffusion in the in the core of that

249  
00:10:29,509 --> 00:10:35,419  
star is no longer able to counteract the

250  
00:10:32,690 --> 00:10:37,160  
force of gravity and and so the star

251  
00:10:35,419 --> 00:10:39,979  
collapses in on itself and that can

252  
00:10:37,159 --> 00:10:42,199  
cause an explosion and it's that release

253  
00:10:39,980 --> 00:10:43,789  
that like you know nearly instantaneous

254  
00:10:42,200 --> 00:10:46,459  
release of gravitational energy that's

255  
00:10:43,789 --> 00:10:49,789  
that's very explodes to that explosion

256  
00:10:46,458 --> 00:10:54,259  
Wow for the white dwarf on the other

257

00:10:49,789 --> 00:10:57,528  
hand if if you slowly add material to it

258  
00:10:54,259 --> 00:10:58,939  
it'll become more massive and because

259  
00:10:57,528 --> 00:11:00,409  
it's more massive and a white dwarf is a

260  
00:10:58,940 --> 00:11:02,660  
very funny object that's called a

261  
00:11:00,409 --> 00:11:04,789  
degenerate object we don't need to get

262  
00:11:02,659 --> 00:11:07,519  
into the details of it but what it means

263  
00:11:04,789 --> 00:11:10,309  
is that the more massive it becomes the

264  
00:11:07,519 --> 00:11:12,620  
it actually gets and so the density goes

265  
00:11:10,309 --> 00:11:14,989  
really it goes up a lot because you're

266  
00:11:12,620 --> 00:11:17,870  
making it the mass higher and the the

267  
00:11:14,990 --> 00:11:19,940  
size of it smaller so as the density

268  
00:11:17,870 --> 00:11:22,820  
increases eventually you get to a point

269  
00:11:19,940 --> 00:11:24,290  
where you you have so many carbon atoms

270  
00:11:22,820 --> 00:11:26,960  
that are really close together that the

271  
00:11:24,289 --> 00:11:28,429

carbon will will fuse together and when

272

00:11:26,960 --> 00:11:30,350

that happens when you when you take it

273

00:11:28,429 --> 00:11:32,149

you know carbon atom carbon atom and you

274

00:11:30,350 --> 00:11:35,509

fuse them together that's nuclear fusion

275

00:11:32,149 --> 00:11:37,519

it releases energy and the conditions of

276

00:11:35,509 --> 00:11:39,319

the weight or if are such that you know

277

00:11:37,519 --> 00:11:41,120

once you start that process it becomes a

278

00:11:39,320 --> 00:11:44,650

runaway and it'll burn through the

279

00:11:41,120 --> 00:11:47,690

entire star and that explosion is is

280

00:11:44,649 --> 00:11:49,850

it's what we call a supernova as well so

281

00:11:47,690 --> 00:11:51,410

you described white dwarves as

282

00:11:49,850 --> 00:11:53,269

degenerate stars and I love that because

283

00:11:51,409 --> 00:11:56,860

anytime we can use that word in

284

00:11:53,269 --> 00:11:59,059

astronomy it makes me laugh but the the

285

00:11:56,860 --> 00:12:02,169

where did the white dwarf come from to

286  
00:11:59,059 --> 00:12:05,479  
be able to have that happen right so

287  
00:12:02,169 --> 00:12:08,240  
again the white dwarf is sort of the the

288  
00:12:05,480 --> 00:12:10,789  
end of life for most starts the star

289  
00:12:08,240 --> 00:12:12,350  
like our Sun after it burns all the

290  
00:12:10,789 --> 00:12:13,490  
hydrogen into helium and then it goes

291  
00:12:12,350 --> 00:12:16,279  
through this other phase where it'll

292  
00:12:13,490 --> 00:12:18,350  
burn the helium that that it generates

293  
00:12:16,279 --> 00:12:21,350  
now into heavier elements like carbon

294  
00:12:18,350 --> 00:12:23,000  
and oxygen eventually because it's not

295  
00:12:21,350 --> 00:12:24,620  
so massive it can't continue to burn

296  
00:12:23,000 --> 00:12:27,529  
heavier heavier elements and it just

297  
00:12:24,620 --> 00:12:29,870  
stops and the core of That star after

298  
00:12:27,529 --> 00:12:31,970  
that fusion has essentially stopped is

299  
00:12:29,870 --> 00:12:35,000  
then the white dwarf and a white dwarf

300  
00:12:31,970 --> 00:12:37,670  
is about the size of the earth you know

301  
00:12:35,000 --> 00:12:39,590  
it's it's not huge but much bigger than

302  
00:12:37,669 --> 00:12:40,789  
you know what the universe is my

303  
00:12:39,590 --> 00:12:43,100  
confusion though used to this that's

304  
00:12:40,789 --> 00:12:45,769  
what's gonna happen to our son yes but

305  
00:12:43,100 --> 00:12:49,159  
Marcelle never explode eight eight solar

306  
00:12:45,769 --> 00:12:52,879  
masses or greater so how can a star that

307  
00:12:49,159 --> 00:12:54,529  
big get a do they make orbs to I'm yeah

308  
00:12:52,879 --> 00:12:56,000  
suit so if you're above if you're above

309  
00:12:54,529 --> 00:12:57,079  
ten solar masses you'll never get to a

310  
00:12:56,000 --> 00:12:59,149  
white dwarf because you'll have a

311  
00:12:57,080 --> 00:13:00,710  
supernova before that can happen okay so

312  
00:12:59,149 --> 00:13:02,870  
this subset that we're talking about

313  
00:13:00,710 --> 00:13:07,460  
this white dwarf or a supernova

314

00:13:02,870 --> 00:13:09,080  
yes is nowhere near as common he's not

315  
00:13:07,460 --> 00:13:12,290  
telling you part of this story

316  
00:13:09,080 --> 00:13:14,690  
oh not telling you about the companion

317  
00:13:12,289 --> 00:13:17,539  
oh I told you about the compare we do

318  
00:13:14,690 --> 00:13:19,400  
hear it okay say again so we're

319  
00:13:17,539 --> 00:13:22,629  
envisioning this white dwarf like the

320  
00:13:19,399 --> 00:13:22,629  
Sun except it's not like

321  
00:13:23,080 --> 00:13:30,710  
that's where the extra stuff so that the

322  
00:13:27,649 --> 00:13:32,689  
Sun will never explode and most white

323  
00:13:30,710 --> 00:13:35,750  
dwarfs will never explode only a small

324  
00:13:32,690 --> 00:13:37,910  
subset that have companions and the

325  
00:13:35,750 --> 00:13:40,250  
conditions have to be right so that you

326  
00:13:37,909 --> 00:13:42,769  
can transfer some of the material from

327  
00:13:40,250 --> 00:13:45,470  
the companion to the white dwarf in the

328  
00:13:42,769 --> 00:13:47,840

right way and if you do everything just

329

00:13:45,470 --> 00:13:49,730

right then you get a supernova okay good

330

00:13:47,840 --> 00:13:51,259

there we go I just want to make that

331

00:13:49,730 --> 00:13:54,560

case god I don't know if you have it

332

00:13:51,259 --> 00:13:58,129

handy but there was a graphic of that I

333

00:13:54,559 --> 00:13:59,509

think sent by Curtis pointing that look

334

00:13:58,129 --> 00:14:01,309

just sort of an artist rendition of what

335

00:13:59,509 --> 00:14:05,330

that looks like but you can't find

336

00:14:01,309 --> 00:14:07,099

that's okay but in terms of how common

337

00:14:05,330 --> 00:14:09,139

each of these subs you know each of

338

00:14:07,100 --> 00:14:12,350

these types of supernovae are they're

339

00:14:09,139 --> 00:14:14,419

roughly the same although the the kind

340

00:14:12,350 --> 00:14:17,690

from more massive stars are slightly

341

00:14:14,419 --> 00:14:20,769

more common in terms of how often they

342

00:14:17,690 --> 00:14:23,810

occur but just because of the the



343  
00:14:20,769 --> 00:14:25,399  
characteristics of of the explosions the

344  
00:14:23,809 --> 00:14:27,739  
the white dwarf supernovae tend to be

345  
00:14:25,399 --> 00:14:33,590  
brighter and so we find more of them

346  
00:14:27,740 --> 00:14:34,850  
generally they're brighter okay so so

347  
00:14:33,590 --> 00:14:36,050  
before we leave this topic and while

348  
00:14:34,850 --> 00:14:38,149  
we're on that we've mentioned our own

349  
00:14:36,049 --> 00:14:39,259  
Sun a couple of times Curtis can I let

350  
00:14:38,149 --> 00:14:40,220  
me get you in the conversation a little

351  
00:14:39,259 --> 00:14:42,309  
bit let me ask you

352  
00:14:40,220 --> 00:14:44,750  
we've already just we've already our

353  
00:14:42,309 --> 00:14:47,629  
Ryan's already told us that our Suns not

354  
00:14:44,750 --> 00:14:49,220  
going to blow up what will it do so at

355  
00:14:47,629 --> 00:14:50,779  
the end of its life it's going to

356  
00:14:49,220 --> 00:14:51,889  
transition from burning hydrogen into

357  
00:14:50,779 --> 00:14:54,110  
start and it's going to start burning

358  
00:14:51,889 --> 00:14:55,699  
helium in the core and it's going to as

359  
00:14:54,110 --> 00:14:59,269  
Ryan mentioned before it's going to puff

360  
00:14:55,700 --> 00:15:01,100  
up into a red giant and kind of at the

361  
00:14:59,269 --> 00:15:03,019  
end of all of this cycle it's going to

362  
00:15:01,100 --> 00:15:04,639  
blow off the outer layers kind of puff

363  
00:15:03,019 --> 00:15:07,610  
off the outer layers I'm not really an

364  
00:15:04,639 --> 00:15:10,250  
explosion but something a little gentler

365  
00:15:07,610 --> 00:15:11,659  
and it's going to create something that

366  
00:15:10,250 --> 00:15:13,940  
looks like a nebula and what's going to

367  
00:15:11,659 --> 00:15:16,519  
be left is a carbon and oxygen white

368  
00:15:13,940 --> 00:15:18,740  
dwarf okay so Scott put you you had it

369  
00:15:16,519 --> 00:15:21,110  
up briefly can you show one more time

370  
00:15:18,740 --> 00:15:23,840  
I'm gonna put this up all curtis's to

371

00:15:21,110 --> 00:15:26,120  
illustrate this point so our Sun when it

372  
00:15:23,840 --> 00:15:28,340  
goes when it dies we'll leave behind a

373  
00:15:26,120 --> 00:15:31,240  
white dwarf star this won't be what

374  
00:15:28,340 --> 00:15:33,680  
happens in our particular case but the

375  
00:15:31,240 --> 00:15:34,680  
some white dwarfs have a companion a

376  
00:15:33,679 --> 00:15:37,049  
nearby star

377  
00:15:34,679 --> 00:15:39,269  
are from which it can draw material and

378  
00:15:37,049 --> 00:15:41,129  
here's the cartoon showing that now that

379  
00:15:39,269 --> 00:15:42,809  
Scott has up and you can see there's a

380  
00:15:41,129 --> 00:15:45,870  
there's a big much bigger star

381  
00:15:42,809 --> 00:15:48,149  
surrounding and orbiting in unison with

382  
00:15:45,870 --> 00:15:51,810  
a with a slower white dwarf these things

383  
00:15:48,149 --> 00:15:52,889  
are very dense as Ryan pointed out it's

384  
00:15:51,809 --> 00:15:54,539  
one of those things you hear in high

385  
00:15:52,889 --> 00:15:56,879

school all the time 1 tablespoon

386

00:15:54,539 --> 00:15:59,610  
spoonful of this stuff will weigh

387

00:15:56,879 --> 00:16:01,860  
bajillions of tons and you know your

388

00:15:59,610 --> 00:16:04,110  
mind goes like okay that's a lot that's

389

00:16:01,860 --> 00:16:06,480  
a big number but suffice it to say these

390

00:16:04,110 --> 00:16:08,909  
are dense objects and and here's a

391

00:16:06,480 --> 00:16:11,000  
cartoon of what Ryan was talking about

392

00:16:08,909 --> 00:16:15,360  
so for supernovae like this to occur

393

00:16:11,000 --> 00:16:18,919  
Ryan it has to gather enough matter or

394

00:16:15,360 --> 00:16:21,889  
mass from this other star to reignite

395

00:16:18,919 --> 00:16:24,449  
fusion within the degenerate star right

396

00:16:21,889 --> 00:16:27,049  
yeah that's correct in fact the the

397

00:16:24,450 --> 00:16:29,640  
picture that you're showing is a very

398

00:16:27,049 --> 00:16:31,139  
particular and very very interesting

399

00:16:29,639 --> 00:16:35,069  
especially for the people on this call

400  
00:16:31,139 --> 00:16:36,419  
type of supernova and and so you're

401  
00:16:35,070 --> 00:16:37,649  
absolutely right is the same kind of

402  
00:16:36,419 --> 00:16:40,708  
thing that we've talked about but this

403  
00:16:37,649 --> 00:16:42,600  
specific example I'm sure will get into

404  
00:16:40,708 --> 00:16:46,109  
this eventually we think that although

405  
00:16:42,600 --> 00:16:49,080  
you'll have a runaway nuclear reaction

406  
00:16:46,110 --> 00:16:56,639  
that will cause an explosion the star

407  
00:16:49,080 --> 00:17:02,400  
itself may survive so I have I have a

408  
00:16:56,639 --> 00:17:07,740  
question Carol your hand question I have

409  
00:17:02,399 --> 00:17:09,410  
to raise my hand but you don't so so I

410  
00:17:07,740 --> 00:17:13,410  
know you're going to talk about how you

411  
00:17:09,410 --> 00:17:15,509  
determine in detail using Hubble and

412  
00:17:13,410 --> 00:17:19,339  
other observatories but the first

413  
00:17:15,509 --> 00:17:22,199  
question is we know they get bright so

414  
00:17:19,338 --> 00:17:24,240  
somebody discovers it maybe even

415  
00:17:22,199 --> 00:17:28,289  
somebody at Las Cumbres discovers a

416  
00:17:24,240 --> 00:17:31,529  
supernova and then how do you know right

417  
00:17:28,289 --> 00:17:34,079  
off the bat what type of supernova is

418  
00:17:31,529 --> 00:17:37,109  
before you decide to start investigating

419  
00:17:34,079 --> 00:17:39,089  
it in great detail on maybe looking at

420  
00:17:37,109 --> 00:17:41,279  
its companion oh it's see if it has a

421  
00:17:39,089 --> 00:17:44,009  
binary star or whatever so how do you

422  
00:17:41,279 --> 00:17:46,470  
how do we know the type what makes it a

423  
00:17:44,009 --> 00:17:48,329  
type yeah so there are a bunch of

424  
00:17:46,470 --> 00:17:48,569  
different types of these supernovae and

425  
00:17:48,329 --> 00:17:50,490  
there's

426  
00:17:48,569 --> 00:17:52,980  
sort of two ways that we like to

427  
00:17:50,490 --> 00:17:54,690  
classify them one is like trying to

428

00:17:52,980 --> 00:17:56,130  
understand what kind of system was it

429  
00:17:54,690 --> 00:17:57,960  
was it a massive star with the first

430  
00:17:56,130 --> 00:17:59,580  
kind that Ryan mentioned or was it one

431  
00:17:57,960 --> 00:18:01,860  
of these white dwarf supernovae and so

432  
00:17:59,579 --> 00:18:03,888  
that's like a physical kind of type what

433  
00:18:01,859 --> 00:18:05,788  
was the system that exploded

434  
00:18:03,888 --> 00:18:07,589  
unfortunately we don't usually get to

435  
00:18:05,788 --> 00:18:09,028  
see the system you know we're not there

436  
00:18:07,589 --> 00:18:11,339  
so we don't get to see it we just get to

437  
00:18:09,028 --> 00:18:13,259  
see the light from the system so what we

438  
00:18:11,339 --> 00:18:15,209  
really get is we usually go and take a

439  
00:18:13,259 --> 00:18:17,429  
spectrum so we take that light we spread

440  
00:18:15,210 --> 00:18:18,750  
it out into its colors with Hubble for

441  
00:18:17,429 --> 00:18:21,179  
instance we can do that especially in

442  
00:18:18,750 --> 00:18:22,500

the ultraviolet and other parts of the

443

00:18:21,179 --> 00:18:24,419  
spectrum but usually we can also do it

444

00:18:22,500 --> 00:18:26,878  
just from the ground-based telescopes in

445

00:18:24,419 --> 00:18:29,070  
the visible and then we looked for what

446

00:18:26,878 --> 00:18:31,648  
elements are in that spectrum and that

447

00:18:29,069 --> 00:18:34,439  
gives us a hint as to what of the which

448

00:18:31,648 --> 00:18:36,239  
of these kinds of supernovae they are

449

00:18:34,440 --> 00:18:37,830  
what what kind of stories came from

450

00:18:36,240 --> 00:18:40,798  
actually for a long time so people have

451

00:18:37,829 --> 00:18:43,829  
been doing this for decades and like in

452

00:18:40,798 --> 00:18:46,259  
the 50s and 60s people would get CDs new

453

00:18:43,829 --> 00:18:48,599  
stars these exploded stars they would

454

00:18:46,259 --> 00:18:50,308  
get a spectrum and they would say oh it

455

00:18:48,599 --> 00:18:52,619  
looks like it has hydrogen in it we're

456

00:18:50,308 --> 00:18:53,759  
gonna call that a type 2 and here's one



457  
00:18:52,619 --> 00:18:55,949  
that doesn't have hydrogen we're gonna

458  
00:18:53,759 --> 00:18:57,690  
call that a type 1 and they didn't know

459  
00:18:55,950 --> 00:18:59,308  
what kind of stars were necessarily

460  
00:18:57,690 --> 00:19:01,139  
responsible for those two different

461  
00:18:59,308 --> 00:19:03,089  
types so they just kind of classified

462  
00:19:01,138 --> 00:19:04,949  
them based on what this spectrum was and

463  
00:19:03,089 --> 00:19:06,869  
we still do that today so we we have all

464  
00:19:04,950 --> 00:19:10,288  
these different types the type 1 that

465  
00:19:06,869 --> 00:19:11,908  
later got subdivided into type 1a 1b 1c

466  
00:19:10,288 --> 00:19:14,158  
and then type twos and then there are

467  
00:19:11,909 --> 00:19:16,379  
even some other types that in fact some

468  
00:19:14,159 --> 00:19:18,750  
of us totally Ryan have helped coin and

469  
00:19:16,378 --> 00:19:20,428  
the big goal actually in supernova

470  
00:19:18,750 --> 00:19:22,528  
research is to connect the type of

471  
00:19:20,429 --> 00:19:25,500  
supernova we see from the data from the

472  
00:19:22,528 --> 00:19:26,819  
spectrum that we measure - this is or

473  
00:19:25,500 --> 00:19:29,250  
was it well it one of these massive

474  
00:19:26,819 --> 00:19:30,990  
stars that are on here now it turns out

475  
00:19:29,250 --> 00:19:33,240  
that we think the type twos and the one

476  
00:19:30,990 --> 00:19:35,399  
B's and once C's come from this kind of

477  
00:19:33,240 --> 00:19:37,319  
massive star configuration whereas the

478  
00:19:35,398 --> 00:19:39,268  
white dwarf supernovae mostly account

479  
00:19:37,319 --> 00:19:40,648  
for the type 1a s but that was actually

480  
00:19:39,269 --> 00:19:44,250  
only knowledge that was sort of gained

481  
00:19:40,648 --> 00:19:45,959  
through observation and modeling of the

482  
00:19:44,250 --> 00:19:47,519  
supernovae together to kind of come

483  
00:19:45,960 --> 00:19:49,079  
together through a consistent picture

484  
00:19:47,519 --> 00:19:51,628  
but still the forefront of research

485

00:19:49,079 --> 00:19:54,569  
connecting the data to what actually

486  
00:19:51,628 --> 00:19:57,418  
exploded and you have to catch them

487  
00:19:54,569 --> 00:20:00,298  
pretty quick right I mean you have to

488  
00:19:57,419 --> 00:20:02,220  
so there are searches to try to find the

489  
00:20:00,298 --> 00:20:04,109  
supernova and then immediately

490  
00:20:02,220 --> 00:20:05,700  
we start observing them as because you

491  
00:20:04,109 --> 00:20:08,339  
want to catch them as close as you can

492  
00:20:05,700 --> 00:20:10,650  
to when they go up right that's right

493  
00:20:08,339 --> 00:20:12,298  
yeah I mean the earlier you can you can

494  
00:20:10,650 --> 00:20:14,220  
see them you can see different parts of

495  
00:20:12,298 --> 00:20:15,750  
the supernova actually as time goes on

496  
00:20:14,220 --> 00:20:17,308  
you usually can see deeper and deeper

497  
00:20:15,750 --> 00:20:20,369  
into the supernova so you learn about

498  
00:20:17,308 --> 00:20:21,658  
the structure so in that massive star

499  
00:20:20,369 --> 00:20:23,788

diagram where you have that kind of

500

00:20:21,659 --> 00:20:25,500

onion skin structure you can see

501

00:20:23,788 --> 00:20:28,650

different elements in different layers

502

00:20:25,500 --> 00:20:30,029

of the deeper but one of the important

503

00:20:28,650 --> 00:20:32,070

reasons to you know try and study them

504

00:20:30,029 --> 00:20:33,538

one day when you first go off is because

505

00:20:32,069 --> 00:20:34,918

they're they're usually not too much you

506

00:20:33,538 --> 00:20:36,690

know they may take a couple weeks to get

507

00:20:34,919 --> 00:20:38,220

to their peak brightness but after that

508

00:20:36,690 --> 00:20:39,509

it's all downhill so you want to study

509

00:20:38,220 --> 00:20:41,038

them when they're bright when we can

510

00:20:39,509 --> 00:20:43,859

collect the most light from them and

511

00:20:41,038 --> 00:20:45,390

learn the most about them okay so I also

512

00:20:43,859 --> 00:20:46,889

Curtis you had a diagram of the

513

00:20:45,390 --> 00:20:52,980

different types can you put that back up

514  
00:20:46,890 --> 00:20:54,090  
please so there so there are well let's

515  
00:20:52,980 --> 00:20:55,440  
just talk about all the different cut

516  
00:20:54,089 --> 00:20:56,939  
types that there are and that's just

517  
00:20:55,440 --> 00:20:58,919  
going to detail about them now we know

518  
00:20:56,940 --> 00:21:01,200  
that they get they you know we get them

519  
00:20:58,919 --> 00:21:02,490  
quickly we and we'll talk about the way

520  
00:21:01,200 --> 00:21:04,259  
it are discovered in a minute but we

521  
00:21:02,490 --> 00:21:07,589  
have here according to what Curtis is

522  
00:21:04,259 --> 00:21:11,129  
showing a type 1 a type 1 B 1 Z and a

523  
00:21:07,589 --> 00:21:13,730  
type 2 uh who wants to go through some

524  
00:21:11,130 --> 00:21:16,559  
of these or like type 1a they're very

525  
00:21:13,730 --> 00:21:18,929  
they're very special kind of supernovae

526  
00:21:16,558 --> 00:21:22,308  
they they're really useful in a lot of

527  
00:21:18,929 --> 00:21:24,650  
ways Ryan can you tell us about these

528

00:21:22,308 --> 00:21:33,990

yeah absolutely

529

00:21:24,650 --> 00:21:36,780

so the second best now but no so you

530

00:21:33,990 --> 00:21:39,210

know tech 1a I wrote my my PhD thesis on

531

00:21:36,779 --> 00:21:41,629

type 1a supernovae there's always a

532

00:21:39,210 --> 00:21:44,929

special place in my heart for them and

533

00:21:41,630 --> 00:21:47,610

and they're they are exceptionally

534

00:21:44,929 --> 00:21:48,419

important objects for understanding the

535

00:21:47,609 --> 00:21:51,000

universe as a whole

536

00:21:48,419 --> 00:21:53,220

which you know if you think about this

537

00:21:51,000 --> 00:21:55,230

this tiny star somewhere in some distant

538

00:21:53,220 --> 00:21:59,100

galaxy exploding and that's supposed to

539

00:21:55,230 --> 00:22:01,589

tell us about the entire the entirety of

540

00:21:59,099 --> 00:22:04,109

the universe that's that's important so

541

00:22:01,589 --> 00:22:05,788

the type 1a you know if you're if you're

542

00:22:04,109 --> 00:22:08,869  
looking at curtis's little diagram he's

543  
00:22:05,788 --> 00:22:11,460  
got this very nice final line that

544  
00:22:08,869 --> 00:22:15,029  
distinguishes from the the type which is

545  
00:22:11,460 --> 00:22:16,110  
based on the observations with our

546  
00:22:15,029 --> 00:22:19,519  
physical interpret

547  
00:22:16,109 --> 00:22:22,500  
and so the type 1a is this thermonuclear

548  
00:22:19,519 --> 00:22:25,289  
explosion this is what we think is

549  
00:22:22,500 --> 00:22:28,259  
coming from a white dwarf that explodes

550  
00:22:25,289 --> 00:22:32,308  
it has a thermonuclear explosion that

551  
00:22:28,259 --> 00:22:35,640  
will completely shred this star and as a

552  
00:22:32,308 --> 00:22:37,920  
result generate a bunch of radioactive

553  
00:22:35,640 --> 00:22:41,190  
material in particular radioactive

554  
00:22:37,920 --> 00:22:44,700  
nickel and that radioactive nickel

555  
00:22:41,190 --> 00:22:48,720  
decays first to cobalt and then to iron

556  
00:22:44,700 --> 00:22:51,120

which is stable and in that process the

557

00:22:48,720 --> 00:22:56,569

energy that's released on timescales of

558

00:22:51,119 --> 00:23:00,599

days weeks months is injected into the

559

00:22:56,569 --> 00:23:02,668

material that the supernova ejected

560

00:23:00,599 --> 00:23:06,119

outward that's that's the shredded star

561

00:23:02,669 --> 00:23:09,900

and then that material glows and that's

562

00:23:06,119 --> 00:23:12,239

what we see is supernovae now the this

563

00:23:09,900 --> 00:23:13,919

type of supernova because of some of the

564

00:23:12,240 --> 00:23:16,410

intrinsic properties of the explosion

565

00:23:13,919 --> 00:23:19,740

and the star system that they come from

566

00:23:16,410 --> 00:23:22,080

they all seem to be about the same

567

00:23:19,740 --> 00:23:25,380

intrinsic brightness and so we call them

568

00:23:22,079 --> 00:23:27,480

standard candles and in much the same

569

00:23:25,380 --> 00:23:30,870

way that you can when you're driving at

570

00:23:27,480 --> 00:23:32,789

night on on the highway and you see



571  
00:23:30,869 --> 00:23:34,589  
distant lights from a car you can

572  
00:23:32,789 --> 00:23:36,928  
estimate how far away that car is by

573  
00:23:34,589 --> 00:23:39,869  
noticing how bright the the headlights

574  
00:23:36,929 --> 00:23:42,990  
appeared to you since you know roughly

575  
00:23:39,869 --> 00:23:45,149  
how bright a headlight should be you can

576  
00:23:42,990 --> 00:23:48,000  
estimate how far away it is we do the

577  
00:23:45,150 --> 00:23:49,950  
same thing for supernovae we have some

578  
00:23:48,000 --> 00:23:52,798  
idea of how intrinsically bright they

579  
00:23:49,950 --> 00:23:56,519  
are we measure how bright they appear

580  
00:23:52,798 --> 00:23:59,639  
here and so from those two measurements

581  
00:23:56,519 --> 00:24:01,619  
we can estimate the distance and yeah

582  
00:23:59,640 --> 00:24:02,940  
that's a huge point I'm really I really

583  
00:24:01,619 --> 00:24:05,159  
want to make sure people understand this

584  
00:24:02,940 --> 00:24:07,289  
because imagine taking a candle folks

585  
00:24:05,160 --> 00:24:08,640  
right next to your face it's gonna have

586  
00:24:07,289 --> 00:24:10,440  
a certain brightness you're gonna feel

587  
00:24:08,640 --> 00:24:12,390  
the heat from it don't burn your hair

588  
00:24:10,440 --> 00:24:13,890  
but the you it's gonna have a certain

589  
00:24:12,390 --> 00:24:16,200  
brightness you measure that brightness

590  
00:24:13,890 --> 00:24:18,120  
of what it is right by your face and you

591  
00:24:16,200 --> 00:24:20,970  
move it and put it across the room it's

592  
00:24:18,119 --> 00:24:23,399  
gonna be dimmer how much dimmer it is

593  
00:24:20,970 --> 00:24:25,130  
will be related to its distance and the

594  
00:24:23,400 --> 00:24:27,720  
only way you can know how far away it is

595  
00:24:25,130 --> 00:24:29,940  
isn't you know how bright it is far away

596  
00:24:27,720 --> 00:24:31,470  
is knowing how bright it

597  
00:24:29,940 --> 00:24:34,649  
be if it were right in front of your

598  
00:24:31,470 --> 00:24:36,899  
face and knowing that and that's is is

599

00:24:34,648 --> 00:24:38,819  
an important element in measuring how

600  
00:24:36,898 --> 00:24:43,138  
far away things are and that's why type

601  
00:24:38,819 --> 00:24:45,269  
1a supernovae are so useful so in

602  
00:24:43,138 --> 00:24:47,459  
addition to that it's that all of these

603  
00:24:45,269 --> 00:24:49,440  
candles you know we don't get the

604  
00:24:47,460 --> 00:24:51,210  
opportunity to move the candle close to

605  
00:24:49,440 --> 00:24:53,700  
us and see how intrinsically bright it

606  
00:24:51,210 --> 00:24:57,000  
is right but we know that the you know

607  
00:24:53,700 --> 00:24:58,980  
that the candle store makes you know all

608  
00:24:57,000 --> 00:25:01,319  
the same brightness candles and so the

609  
00:24:58,980 --> 00:25:03,569  
supernova store also happens to make all

610  
00:25:01,319 --> 00:25:06,138  
the same type 1a supernovae brightnesses

611  
00:25:03,569 --> 00:25:08,250  
or about that Oh Curtis has a great

612  
00:25:06,138 --> 00:25:11,548  
graphic up while you're talking go ahead

613  
00:25:08,250 --> 00:25:13,980

and so so from that we can measure

614

00:25:11,548 --> 00:25:15,990

distances and because type 1a supernovae

615

00:25:13,980 --> 00:25:17,819

are also in addition to being these

616

00:25:15,990 --> 00:25:20,220

standard candles they're also very very

617

00:25:17,819 --> 00:25:22,769

luminous they're intrinsically bright we

618

00:25:20,220 --> 00:25:25,788

can see them very far away billions of

619

00:25:22,769 --> 00:25:28,378

light years away and and from that

620

00:25:25,788 --> 00:25:31,679

ability to to find things on the other

621

00:25:28,378 --> 00:25:33,628

edge of the universe and then compare

622

00:25:31,679 --> 00:25:35,970

how bright they are to how much the

623

00:25:33,628 --> 00:25:37,859

universe has expanded in the time

624

00:25:35,970 --> 00:25:39,298

between when that supernova explosion

625

00:25:37,859 --> 00:25:41,128

happened because remember billions of

626

00:25:39,298 --> 00:25:44,038

light years away means that it happened

627

00:25:41,128 --> 00:25:46,798

billions of years ago and so you can

628  
00:25:44,038 --> 00:25:48,750  
compare those to the the amount that the

629  
00:25:46,798 --> 00:25:52,138  
universe has expanded during that time

630  
00:25:48,750 --> 00:25:54,690  
to its distance and that that expansion

631  
00:25:52,138 --> 00:25:55,949  
history right because it's it's it's a

632  
00:25:54,690 --> 00:25:58,970  
you know you're looking back in time

633  
00:25:55,950 --> 00:26:01,980  
that expansion history is very much

634  
00:25:58,970 --> 00:26:06,089  
dependent on the exact content of the

635  
00:26:01,980 --> 00:26:08,250  
universe and and this this this ability

636  
00:26:06,089 --> 00:26:11,189  
to measure these distances and compare

637  
00:26:08,250 --> 00:26:14,038  
them to the the expansion to get the

638  
00:26:11,190 --> 00:26:15,980  
expansion history led to an assessment

639  
00:26:14,038 --> 00:26:19,648  
of what the universe was made out of and

640  
00:26:15,980 --> 00:26:22,409  
about fifteen years ago now or not not

641  
00:26:19,648 --> 00:26:24,658  
quite 20 years ago now I I

642

00:26:22,409 --> 00:26:26,940

two groups of astronomers use

643

00:26:24,659 --> 00:26:29,100

observations of type 1a supernovae and

644

00:26:26,940 --> 00:26:31,590

they made this assessment they went

645

00:26:29,099 --> 00:26:34,408

through and they said something is kind

646

00:26:31,589 --> 00:26:38,308

of funny here it looks like there's

647

00:26:34,409 --> 00:26:40,889

there's some sort of anti-gravity in the

648

00:26:38,308 --> 00:26:42,538

universe and they and you know they went

649

00:26:40,888 --> 00:26:43,839

back and looked at some of the notes

650

00:26:42,538 --> 00:26:46,599

from Einstein

651

00:26:43,839 --> 00:26:49,709

he had this this idea of something

652

00:26:46,599 --> 00:26:53,288

called a cosmological constant which

653

00:26:49,710 --> 00:26:57,669

produced sort of a cosmic anti-gravity

654

00:26:53,288 --> 00:26:59,169

and the observations appeared to be that

655

00:26:57,669 --> 00:27:00,520

the universe actually had a very large

656

00:26:59,169 --> 00:27:02,528  
component of something that we now

657  
00:27:00,519 --> 00:27:04,509  
called dark energy and that's

658  
00:27:02,528 --> 00:27:07,210  
essentially just showing our ignorance

659  
00:27:04,509 --> 00:27:08,769  
we don't really know what it is and

660  
00:27:07,210 --> 00:27:10,409  
that's that's actually the majority of

661  
00:27:08,769 --> 00:27:13,028  
the universe it's it's somewhere around

662  
00:27:10,409 --> 00:27:15,429  
70% to the universe is this dark energy

663  
00:27:13,028 --> 00:27:18,038  
and we just figured that out you know

664  
00:27:15,429 --> 00:27:20,048  
you know less than two decades ago and

665  
00:27:18,038 --> 00:27:21,369  
then type 1a supernovae as you pointed

666  
00:27:20,048 --> 00:27:24,129  
out were instrumental in that and it was

667  
00:27:21,369 --> 00:27:25,750  
somebody groups in fact Carolyn we care

668  
00:27:24,130 --> 00:27:27,190  
we got it we got to do a dark energy

669  
00:27:25,750 --> 00:27:29,619  
hang out at some point talk about some

670  
00:27:27,190 --> 00:27:31,870

of this stuff and so it's really worth

671

00:27:29,619 --> 00:27:34,119

pointing out that that Hubble was

672

00:27:31,869 --> 00:27:35,739

instrumental in this as well yeah and

673

00:27:34,119 --> 00:27:37,479

you know sir Rob should really be giving

674

00:27:35,740 --> 00:27:41,140

this because sir Rob was on one of these

675

00:27:37,480 --> 00:27:42,220

teams that that made this discovery did

676

00:27:41,140 --> 00:27:43,538

you have any comment you want to add to

677

00:27:42,220 --> 00:27:44,169

that you've been holding out on the

678

00:27:43,538 --> 00:27:50,470

Seurat

679

00:27:44,169 --> 00:27:52,899

he's been polite it was a very exciting

680

00:27:50,470 --> 00:27:54,250

time let's put it that way yeah pretty

681

00:27:52,898 --> 00:27:56,469

nasty universe was you know I mean it's

682

00:27:54,250 --> 00:27:58,329

it's really strange because it's you

683

00:27:56,470 --> 00:28:00,278

know using these these white dwarf stars

684

00:27:58,329 --> 00:28:01,750

that we don't when they explode we don't



685  
00:28:00,278 --> 00:28:04,569  
really understand how I guess we'll get

686  
00:28:01,750 --> 00:28:05,890  
into that a little bit but we use them

687  
00:28:04,569 --> 00:28:07,148  
still we saw that they're basically all

688  
00:28:05,890 --> 00:28:09,970  
the same so we can measure these

689  
00:28:07,148 --> 00:28:11,528  
distances and we found that the universe

690  
00:28:09,970 --> 00:28:12,880  
of the galaxies in the universe we knew

691  
00:28:11,528 --> 00:28:14,890  
they were expanding away from each other

692  
00:28:12,880 --> 00:28:15,970  
but that they were expanding away faster

693  
00:28:14,890 --> 00:28:17,590  
and faster that we lived in an

694  
00:28:15,970 --> 00:28:19,360  
accelerating universe that was a huge

695  
00:28:17,589 --> 00:28:21,038  
discovery it's like to me through you

696  
00:28:19,359 --> 00:28:22,658  
know something up in the air and instead

697  
00:28:21,038 --> 00:28:25,179  
of it coming back down or instead of it

698  
00:28:22,659 --> 00:28:27,179  
even it's slowing down as it went up it

699  
00:28:25,179 --> 00:28:30,399  
started going faster and faster yeah

700  
00:28:27,179 --> 00:28:31,870  
when you and so we call that wide dark

701  
00:28:30,398 --> 00:28:33,428  
energy but Ryan was exactly right that

702  
00:28:31,869 --> 00:28:35,079  
you know that's just a name for our

703  
00:28:33,429 --> 00:28:37,059  
ignorance and so it's you know that

704  
00:28:35,079 --> 00:28:38,798  
discovery that started from these type

705  
00:28:37,058 --> 00:28:40,720  
1a supernovae is now at the forefront of

706  
00:28:38,798 --> 00:28:42,579  
cosmology trying to understand what this

707  
00:28:40,720 --> 00:28:45,038  
dark energy is that drives our

708  
00:28:42,579 --> 00:28:46,808  
accelerating Edwards well you raise an

709  
00:28:45,038 --> 00:28:48,819  
interesting point and actually Ryan

710  
00:28:46,808 --> 00:28:52,418  
mention as well is that we can't bring

711  
00:28:48,819 --> 00:28:54,908  
those candles to us and so from the

712  
00:28:52,419 --> 00:28:56,610  
signature the observations you say oh

713

00:28:54,909 --> 00:28:59,100  
this seems like it's a type one

714  
00:28:56,609 --> 00:29:02,189  
this one seems like a type 1a and then

715  
00:28:59,099 --> 00:29:04,048  
you said well maybe we don't fully

716  
00:29:02,190 --> 00:29:06,120  
understand how this explosion occurs

717  
00:29:04,048 --> 00:29:08,700  
does that make you nervous I mean what

718  
00:29:06,119 --> 00:29:10,678  
how much do we not know that they're all

719  
00:29:08,700 --> 00:29:14,399  
the same yeah it doesn't make us nervous

720  
00:29:10,679 --> 00:29:16,320  
any idea this was all trying to show

721  
00:29:14,398 --> 00:29:18,058  
that how similar are they and trying to

722  
00:29:16,319 --> 00:29:20,069  
figure out a way we know that actually

723  
00:29:18,058 --> 00:29:21,928  
there's a some variation in how bright

724  
00:29:20,069 --> 00:29:23,939  
these type 1 days are but we can use

725  
00:29:21,929 --> 00:29:26,700  
clues from the light from the supernova

726  
00:29:23,940 --> 00:29:28,590  
itself to correct their brightnesses to

727  
00:29:26,700 --> 00:29:30,569

make them even more standard sometimes

728

00:29:28,589 --> 00:29:34,798

we call them standardized Abul candles

729

00:29:30,569 --> 00:29:36,210

or calibrated candles so yeah we do have

730

00:29:34,798 --> 00:29:38,609

some ways of checking that you know for

731

00:29:36,210 --> 00:29:39,929

instance sometimes we have two type 1a

732

00:29:38,609 --> 00:29:42,449

supernovae that went off in the same

733

00:29:39,929 --> 00:29:43,919

galaxy and so we can check that do they

734

00:29:42,450 --> 00:29:45,808

end up being the same brightness because

735

00:29:43,919 --> 00:29:47,490

they're the same distance away or more

736

00:29:45,808 --> 00:29:50,009

generally two type 1a supernovae at the

737

00:29:47,490 --> 00:29:51,450

same redshift or when we know one should

738

00:29:50,009 --> 00:29:53,638

be twice as far away as the other

739

00:29:51,450 --> 00:29:55,980

because it has twice the red ship nearby

740

00:29:53,638 --> 00:29:57,569

then we know that the one should be that

741

00:29:55,980 --> 00:29:59,460

one should be four times fainter because

742  
00:29:57,569 --> 00:30:01,230  
it was twice as far away so we can check

743  
00:29:59,460 --> 00:30:02,850  
all those things without knowing

744  
00:30:01,230 --> 00:30:04,620  
anything about the explosion really and

745  
00:30:02,849 --> 00:30:06,119  
when we do those checks we see how

746  
00:30:04,619 --> 00:30:07,888  
precise they are and they're remarkably

747  
00:30:06,119 --> 00:30:09,689  
precise we can get with a good light

748  
00:30:07,888 --> 00:30:12,119  
karbala type 1a supernova we can measure

749  
00:30:09,690 --> 00:30:13,558  
its distance to about 10% accuracy or

750  
00:30:12,119 --> 00:30:15,778  
maybe even a little bit better so the

751  
00:30:13,558 --> 00:30:18,119  
right light curve is how bright it gets

752  
00:30:15,778 --> 00:30:19,798  
and then what happens after it starts to

753  
00:30:18,119 --> 00:30:21,239  
fade that's right it's a trace of how

754  
00:30:19,798 --> 00:30:23,519  
bright it is over time and it usually

755  
00:30:21,240 --> 00:30:26,038  
takes you know weeks to months to

756  
00:30:23,519 --> 00:30:27,569  
brighten and then fade away yeah okay

757  
00:30:26,038 --> 00:30:29,609  
while we're on the topic of type 1a

758  
00:30:27,569 --> 00:30:32,210  
supernovae I have a question from bajas

759  
00:30:29,609 --> 00:30:32,209  
Ahmed from

760  
00:30:42,569 --> 00:30:44,629  
you

761  
00:31:04,819 --> 00:31:11,689  
who the command a type 1a supernova what

762  
00:31:08,329 --> 00:31:19,159  
happens to the companion star he wants

763  
00:31:11,690 --> 00:31:21,920  
to take that do you hear me yes I mean I

764  
00:31:19,160 --> 00:31:24,650  
guess I can I can mention this so that

765  
00:31:21,920 --> 00:31:27,500  
the the good question first before you

766  
00:31:24,650 --> 00:31:30,200  
ask what happened to the companion star

767  
00:31:27,500 --> 00:31:34,789  
is to understand what the companion star

768  
00:31:30,200 --> 00:31:38,930  
is and and so for type 1a supernova we

769  
00:31:34,789 --> 00:31:43,129  
have two very very different scenarios

770

00:31:38,930 --> 00:31:45,890  
and and and depending on those two

771  
00:31:43,130 --> 00:31:48,410  
scenarios then it really changes what

772  
00:31:45,890 --> 00:31:50,900  
happens to that companion star so I'll

773  
00:31:48,410 --> 00:31:53,750  
try to generalize this but if I get into

774  
00:31:50,900 --> 00:31:57,140  
jargon somebody stop me the one way is

775  
00:31:53,750 --> 00:31:59,089  
if you have two white dwarfs that slowly

776  
00:31:57,140 --> 00:32:00,920  
come to get when there's something

777  
00:31:59,089 --> 00:32:02,629  
called gravitational radiation and and

778  
00:32:00,920 --> 00:32:04,930  
so that these orbits slowly come

779  
00:32:02,630 --> 00:32:07,550  
together and then eventually they merge

780  
00:32:04,930 --> 00:32:09,650  
another possibility is that you have a

781  
00:32:07,549 --> 00:32:11,960  
white dwarf and then something more like

782  
00:32:09,650 --> 00:32:14,810  
our Sun or a red giant that slowly

783  
00:32:11,960 --> 00:32:16,490  
transfers mass on to the white dwarf so

784  
00:32:14,809 --> 00:32:17,690

in that first scenario where you have

785

00:32:16,490 --> 00:32:20,150

two white dwarfs coming together and

786

00:32:17,690 --> 00:32:23,150

they merge then then that other star is

787

00:32:20,150 --> 00:32:25,670

gone it's it's become you know part of

788

00:32:23,150 --> 00:32:27,650

this you know massive white dwarf for an

789

00:32:25,670 --> 00:32:30,080

instant as the explosion just goes

790

00:32:27,650 --> 00:32:32,240

through it so in that case it's

791

00:32:30,079 --> 00:32:35,029

completely gone just like the the star

792

00:32:32,240 --> 00:32:38,269

that the primary more massive star that

793

00:32:35,029 --> 00:32:41,029

explodes in the other case where there's

794

00:32:38,269 --> 00:32:44,240

something more like our Sun or a big

795

00:32:41,029 --> 00:32:47,119

star I it's a little unclear exactly

796

00:32:44,240 --> 00:32:50,990

what happens you know there was this

797

00:32:47,119 --> 00:32:53,809

giant explosion right nearby and uh and

798

00:32:50,990 --> 00:32:56,029

so something must happen we we have an



799  
00:32:53,809 --> 00:32:57,740  
understanding of that and there have

800  
00:32:56,029 --> 00:32:59,930  
been a lot of theoretical modeling to

801  
00:32:57,740 --> 00:33:01,609  
try to figure this out and so there are

802  
00:32:59,930 --> 00:33:05,750  
a bunch of things that that we know will

803  
00:33:01,609 --> 00:33:07,519  
happen so the supernova shock from from

804  
00:33:05,750 --> 00:33:11,269  
that explosion will go through and

805  
00:33:07,519 --> 00:33:13,279  
eventually hit that star and some of the

806  
00:33:11,269 --> 00:33:16,639  
material from the supernova will be

807  
00:33:13,279 --> 00:33:18,619  
deposited into that star and the

808  
00:33:16,640 --> 00:33:22,550  
combination of those two things

809  
00:33:18,619 --> 00:33:26,209  
I will potentially change the how bright

810  
00:33:22,549 --> 00:33:28,430  
the the star gets and some other aspects

811  
00:33:26,210 --> 00:33:30,558  
of it but the other thing that is very

812  
00:33:28,430 --> 00:33:32,450  
important is that you used to have these

813  
00:33:30,558 --> 00:33:34,700  
two stars in a tight system where they

814  
00:33:32,450 --> 00:33:36,830  
were going around each other right there

815  
00:33:34,700 --> 00:33:38,330  
just orbiting each other and then um you

816  
00:33:36,829 --> 00:33:40,699  
know all of a sudden one is gone and so

817  
00:33:38,329 --> 00:33:42,799  
what happens to the other one this is

818  
00:33:40,700 --> 00:33:44,090  
like if you know if you if you're

819  
00:33:42,799 --> 00:33:46,039  
holding hands with somebody spinning in

820  
00:33:44,089 --> 00:33:49,369  
a circle and you let go right you just

821  
00:33:46,039 --> 00:33:51,379  
fly off and so I you know in in this

822  
00:33:49,369 --> 00:33:53,000  
case when you have these two stars going

823  
00:33:51,380 --> 00:33:54,800  
around each other one just explodes the

824  
00:33:53,000 --> 00:33:57,349  
other star is just going to fly off into

825  
00:33:54,799 --> 00:34:01,009  
space at essentially the the velocity of

826  
00:33:57,349 --> 00:34:03,469  
the of the orbital speed so so those are

827

00:34:01,009 --> 00:34:05,299  
sort of the basics that we know we don't

828  
00:34:03,470 --> 00:34:07,819  
think for instance that the second star

829  
00:34:05,299 --> 00:34:11,418  
will explode that doesn't seem to be the

830  
00:34:07,819 --> 00:34:13,309  
case or something like that I the the

831  
00:34:11,418 --> 00:34:16,460  
actual changes to the star are probably

832  
00:34:13,309 --> 00:34:18,769  
minor but some some models have actually

833  
00:34:16,460 --> 00:34:21,829  
said that they could change in a way

834  
00:34:18,769 --> 00:34:23,539  
that it would be observable so now I

835  
00:34:21,829 --> 00:34:24,829  
have a question about that though

836  
00:34:23,539 --> 00:34:27,139  
because we were we were talking about

837  
00:34:24,829 --> 00:34:30,259  
earlier about the supernova at 10:54 in

838  
00:34:27,139 --> 00:34:32,090  
the Crab Nebula and a few months back I

839  
00:34:30,260 --> 00:34:34,280  
did a show about the Crab Nebula and we

840  
00:34:32,090 --> 00:34:35,629  
can actually see the Pulsar inside of it

841  
00:34:34,280 --> 00:34:38,740

can we go into a little bit of the

842

00:34:35,628 --> 00:34:41,210

Pulsar so here's here's a graphic I made

843

00:34:38,739 --> 00:34:42,829

from observations from Hubble and

844

00:34:41,210 --> 00:34:45,980

Chandra so we can see them the different

845

00:34:42,829 --> 00:34:47,449

wavelengths of what's been observed over

846

00:34:45,980 --> 00:34:49,878

the years and seeing these ripples

847

00:34:47,449 --> 00:34:51,859

through this pulsar wind can we go into

848

00:34:49,878 --> 00:34:55,069

a little bit of that with the supernovae

849

00:34:51,860 --> 00:34:56,899

sure so so the Crab Nebula one because

850

00:34:55,070 --> 00:34:59,360

we see a pulsar there and a pulsar is

851

00:34:56,898 --> 00:35:02,269

just as rapidly very rapidly spinning

852

00:34:59,360 --> 00:35:04,039

neutron star so even more dense than a

853

00:35:02,269 --> 00:35:05,090

white dwarf we talk about white dwarfs

854

00:35:04,039 --> 00:35:07,639

that were roughly the size of the earth

855

00:35:05,090 --> 00:35:09,470

a neutron star is like ten kilometers

856  
00:35:07,639 --> 00:35:12,019  
wide so the size of a kind of a big city

857  
00:35:09,469 --> 00:35:13,429  
so you imagine taking like solar masses

858  
00:35:12,019 --> 00:35:15,980  
of worth of material and really

859  
00:35:13,429 --> 00:35:18,379  
compressing them in to nuclear densities

860  
00:35:15,980 --> 00:35:19,639  
and you get a neutron star so in the in

861  
00:35:18,380 --> 00:35:20,990  
the kind of supernovae that come from

862  
00:35:19,639 --> 00:35:22,819  
the massive stars

863  
00:35:20,989 --> 00:35:24,919  
that's what can be left behind the core

864  
00:35:22,820 --> 00:35:26,570  
collapses all the way down to either a

865  
00:35:24,920 --> 00:35:29,630  
neutron star like in the Crab Nebula

866  
00:35:26,570 --> 00:35:30,950  
case or a black hole and so there's some

867  
00:35:29,630 --> 00:35:32,599  
systems where we might think that

868  
00:35:30,949 --> 00:35:35,899  
there's a black hole there

869  
00:35:32,599 --> 00:35:37,610  
a pulsar and so that that's what's gets

870  
00:35:35,900 --> 00:35:39,860  
left behind the core of the star that

871  
00:35:37,610 --> 00:35:44,690  
actually exploded is that neutron star

872  
00:35:39,860 --> 00:35:46,130  
so it's pretty Wow ok so this is a disco

873  
00:35:44,690 --> 00:35:47,420  
let's go back to the different types

874  
00:35:46,130 --> 00:35:48,710  
real quick let's finish that up by

875  
00:35:47,420 --> 00:35:53,210  
Curtis could you put that back up for

876  
00:35:48,710 --> 00:35:54,920  
that one doc that one type of graphic

877  
00:35:53,210 --> 00:35:56,750  
you had so we hit that's type one we've

878  
00:35:54,920 --> 00:35:58,880  
covered that one there are other types

879  
00:35:56,750 --> 00:36:01,909  
and these were characterized by core

880  
00:35:58,880 --> 00:36:04,039  
collapse supernova first of all what's a

881  
00:36:01,909 --> 00:36:06,710  
core collapse supernova Curtis can you

882  
00:36:04,039 --> 00:36:09,170  
take that one sure so the core collapse

883  
00:36:06,710 --> 00:36:13,159  
supernovae come from these massive stars

884

00:36:09,170 --> 00:36:16,579  
so as Ryan was mentioning before the

885  
00:36:13,159 --> 00:36:18,799  
high mass stars will explode because the

886  
00:36:16,579 --> 00:36:21,259  
core will no longer be able to sustain

887  
00:36:18,800 --> 00:36:24,110  
fusion and eventually it'll collapse

888  
00:36:21,260 --> 00:36:27,770  
under gravity's just the gravitational

889  
00:36:24,110 --> 00:36:30,260  
energy and that's what's being put back

890  
00:36:27,769 --> 00:36:32,659  
into the ejecta so the core collapse

891  
00:36:30,260 --> 00:36:35,660  
supernovae are aptly named in as much

892  
00:36:32,659 --> 00:36:37,730  
that their core collapses and then the

893  
00:36:35,659 --> 00:36:40,849  
outer material the outer envelope it's

894  
00:36:37,730 --> 00:36:43,429  
that inner core and bounces off and it

895  
00:36:40,849 --> 00:36:44,779  
explodes as a supernova and so that

896  
00:36:43,429 --> 00:36:46,579  
pulsar like we were talking about

897  
00:36:44,780 --> 00:36:49,010  
earlier is what's left behind that

898  
00:36:46,579 --> 00:36:53,779

neutron star is what's left behind it's

899

00:36:49,010 --> 00:36:56,210

the core that that of the star that

900

00:36:53,780 --> 00:36:58,220

exploded so the one that what they

901

00:36:56,210 --> 00:37:00,949

produce the Crab Nebula was a core

902

00:36:58,219 --> 00:37:02,299

collapse supernova then yes okay so and

903

00:37:00,949 --> 00:37:04,789

these can be kind of all over the place

904

00:37:02,300 --> 00:37:06,289

as far as brightness right there there's

905

00:37:04,789 --> 00:37:08,300

nowhere to really I mean they're all

906

00:37:06,289 --> 00:37:10,969

variety of Airy brightness is depending

907

00:37:08,300 --> 00:37:14,240

on what how big they are how massive

908

00:37:10,969 --> 00:37:17,239

they are on a variety of things so

909

00:37:14,239 --> 00:37:20,419

everything from how big they are how

910

00:37:17,239 --> 00:37:21,829

many have a binary a companion just like

911

00:37:20,420 --> 00:37:23,090

the white dwarfs even massive stars can

912

00:37:21,829 --> 00:37:27,699

have binary companions and that can



913  
00:37:23,090 --> 00:37:27,700  
drastically affect their evolution or

914  
00:37:28,360 --> 00:37:32,720  
how much their winds might have actually

915  
00:37:31,130 --> 00:37:34,430  
blown off out of the outer layers the

916  
00:37:32,719 --> 00:37:36,319  
material can also affect things and so

917  
00:37:34,429 --> 00:37:38,629  
there's a lot of different variables in

918  
00:37:36,320 --> 00:37:41,030  
these core collapse supernovae awesome

919  
00:37:38,630 --> 00:37:42,260  
okay so it's really I mean we're using

920  
00:37:41,030 --> 00:37:44,870  
kind of like normal words to describe

921  
00:37:42,260 --> 00:37:46,440  
these really amazing things but every

922  
00:37:44,869 --> 00:37:48,420  
once in a while I like to remind my

923  
00:37:46,440 --> 00:37:50,039  
we're talking about the core of this

924  
00:37:48,420 --> 00:37:52,920  
massive star right before it is about to

925  
00:37:50,039 --> 00:37:55,260  
collapse is almost like a white dwarf

926  
00:37:52,920 --> 00:37:58,230  
at that point it's it's a few solar

927  
00:37:55,260 --> 00:38:00,450  
masses of material the size of the earth

928  
00:37:58,230 --> 00:38:02,880  
so that's already mind-boggling and then

929  
00:38:00,449 --> 00:38:06,029  
in a millisecond it collapses down to

930  
00:38:02,880 --> 00:38:07,559  
ten kilometers oh I know all that energy

931  
00:38:06,030 --> 00:38:10,079  
and the rest of the star gets blown

932  
00:38:07,559 --> 00:38:12,260  
apart I mean it you know that this is

933  
00:38:10,079 --> 00:38:14,099  
why we like to study these things

934  
00:38:12,260 --> 00:38:15,960  
astronomy is full of that kind of stuff

935  
00:38:14,099 --> 00:38:17,338  
that wasn't it I mean we get so so

936  
00:38:15,960 --> 00:38:19,139  
flippant about certain things

937  
00:38:17,338 --> 00:38:21,358  
oh yeah a hundred billion stars in a

938  
00:38:19,139 --> 00:38:23,190  
galaxy 100 billion galaxies the universe

939  
00:38:21,358 --> 00:38:24,869  
yeah you just were to say things you

940  
00:38:23,190 --> 00:38:27,210  
know and it's just when you really stop

941

00:38:24,869 --> 00:38:28,559  
to think about what this means I can

942  
00:38:27,210 --> 00:38:31,679  
really be quite humbling Scott what are

943  
00:38:28,559 --> 00:38:34,410  
you showing this is another one of the

944  
00:38:31,679 --> 00:38:36,750  
graphics I made for that show or the

945  
00:38:34,409 --> 00:38:39,538  
neutron star there it's one the mass of

946  
00:38:36,750 --> 00:38:43,108  
one point four Suns in a twenty

947  
00:38:39,539 --> 00:38:44,460  
kilometer diameter yeah all of you know

948  
00:38:43,108 --> 00:38:45,929  
and it's gonna be a little hard to see

949  
00:38:44,460 --> 00:38:47,309  
here on and the hang-up because it is a

950  
00:38:45,929 --> 00:38:48,629  
really quick image so I'm gonna be

951  
00:38:47,309 --> 00:38:50,579  
putting it into the event page and

952  
00:38:48,630 --> 00:38:53,220  
tweeting it out here in a second but

953  
00:38:50,579 --> 00:38:56,099  
it's really crazy to think about a

954  
00:38:53,219 --> 00:38:58,439  
twenty kilometer diameter but the same

955  
00:38:56,099 --> 00:39:00,599

you know it's more massive than our Sun

956

00:38:58,440 --> 00:39:03,869

almost one and a half of the masses of

957

00:39:00,599 --> 00:39:07,579

our Sun in that small small volume

958

00:39:03,869 --> 00:39:07,579

that'll fit in the Beltway Ivana Carroll

959

00:39:07,849 --> 00:39:26,130

someday she would be the light so

960

00:39:23,278 --> 00:39:27,900

that'll speed up your community oh god

961

00:39:26,130 --> 00:39:29,220

we sure need that but they're

962

00:39:27,900 --> 00:39:34,108

spaghettification that might be

963

00:39:29,219 --> 00:39:36,358

happening okay what I want to cover a

964

00:39:34,108 --> 00:39:37,650

couple more basics on on supernovae they

965

00:39:36,358 --> 00:39:43,048

don't want to talk into some specifics

966

00:39:37,650 --> 00:39:48,900

of specific Hubble observations so we

967

00:39:43,048 --> 00:39:50,250

know that that supernovae are what

968

00:39:48,900 --> 00:39:52,440

they're what we they had different types

969

00:39:50,250 --> 00:39:55,019

or different brightnesses how often do

970  
00:39:52,440 --> 00:39:59,278  
these things occur how common is a

971  
00:39:55,019 --> 00:40:00,119  
supernova explosion Jen when how often

972  
00:39:59,278 --> 00:40:03,000  
is okay

973  
00:40:00,119 --> 00:40:05,880  
to simplify the question in our galaxy

974  
00:40:03,000 --> 00:40:09,360  
the Milky Way how many times will we see

975  
00:40:05,880 --> 00:40:11,670  
an explosion like this you just made it

976  
00:40:09,360 --> 00:40:18,599  
harder well I'm either harder yeah bison

977  
00:40:11,670 --> 00:40:20,909  
all right okay in the Union so the

978  
00:40:18,599 --> 00:40:24,690  
number I remember is in the visible

979  
00:40:20,909 --> 00:40:27,679  
universe there's one every second in our

980  
00:40:24,690 --> 00:40:29,909  
galaxy there's roughly one every century

981  
00:40:27,679 --> 00:40:32,819  
off but that doesn't mean that we see

982  
00:40:29,909 --> 00:40:34,500  
them all because of just our location in

983  
00:40:32,820 --> 00:40:37,170  
the galaxy where in the disk of the

984  
00:40:34,500 --> 00:40:39,750  
galaxy most of the stars are in the disk

985  
00:40:37,170 --> 00:40:41,760  
as well and there's a lot of dust in in

986  
00:40:39,750 --> 00:40:43,170  
the disk and so most of the time we're

987  
00:40:41,760 --> 00:40:46,260  
looking through that dust that dust

988  
00:40:43,170 --> 00:40:48,930  
makes it hard to see other things and so

989  
00:40:46,260 --> 00:40:51,660  
most of the time we we won't see one so

990  
00:40:48,929 --> 00:40:54,539  
the last the last supernova that has

991  
00:40:51,659 --> 00:40:57,539  
definitively been seen by people on

992  
00:40:54,539 --> 00:41:02,309  
earth from our Milky Way was over 400

993  
00:40:57,539 --> 00:41:06,630  
years ago to give an idea Kepler in 1604

994  
00:41:02,309 --> 00:41:09,929  
yeah and uh and and so even though we're

995  
00:41:06,630 --> 00:41:13,010  
do well you could say that but then

996  
00:41:09,929 --> 00:41:16,679  
there was a very nearby supernova in

997  
00:41:13,010 --> 00:41:18,930  
1987 that occurred in a dwarf galaxy

998

00:41:16,679 --> 00:41:22,379  
that orbits the Milky Way so it's right

999  
00:41:18,929 --> 00:41:24,109  
in our backyard and so that happened you

1000  
00:41:22,380 --> 00:41:27,059  
know

1001  
00:41:24,110 --> 00:41:29,910  
it depends on it depends on how you do

1002  
00:41:27,059 --> 00:41:32,579  
your accounting no no I am that doesn't

1003  
00:41:29,909 --> 00:41:34,710  
count the Ryans yeah because uh I mean

1004  
00:41:32,579 --> 00:41:36,809  
I'm Adam 1604 that was the one Kepler

1005  
00:41:34,710 --> 00:41:39,360  
observed his supernova actually just 32

1006  
00:41:36,809 --> 00:41:41,309  
years before in 1572 there was another

1007  
00:41:39,360 --> 00:41:43,230  
Milky Way supernova and so the people

1008  
00:41:41,309 --> 00:41:44,549  
who lived then you know if they had the

1009  
00:41:43,230 --> 00:41:45,690  
Hubble Space Telescope you know they

1010  
00:41:44,550 --> 00:41:48,420  
would have learned all this amazing

1011  
00:41:45,690 --> 00:41:49,710  
stuff about those bogarted all on thirty

1012  
00:41:48,420 --> 00:41:53,849

years in our galaxy

1013

00:41:49,710 --> 00:41:57,139

okay I wanna stick up a little bit for

1014

00:41:53,849 --> 00:41:59,400

1987a because we have lots of HST

1015

00:41:57,139 --> 00:42:02,789

observations we've actually been able to

1016

00:41:59,400 --> 00:42:07,360

see it change over time which has given

1017

00:42:02,789 --> 00:42:11,150

us some interesting information about

1018

00:42:07,360 --> 00:42:13,400

surroundings and honestly from from my

1019

00:42:11,150 --> 00:42:16,070

perspective I would rather see something

1020

00:42:13,400 --> 00:42:18,889

in Andromeda than in the Milky Way

1021

00:42:16,070 --> 00:42:21,590

because in the Milky Way odds are it

1022

00:42:18,889 --> 00:42:23,210

will be in the disc it will have a lot

1023

00:42:21,590 --> 00:42:25,460

of problems actually figuring out what's

1024

00:42:23,210 --> 00:42:28,670

going on whereas Andromeda are the next

1025

00:42:25,460 --> 00:42:30,199

big galaxies it's one of those things

1026

00:42:28,670 --> 00:42:32,809

where you can you can probably make very



1027  
00:42:30,199 --> 00:42:34,099  
precise measurements of it and it's

1028  
00:42:32,809 --> 00:42:36,259  
still close enough where you can get all

1029  
00:42:34,099 --> 00:42:38,960  
this extra data that we're really hoping

1030  
00:42:36,260 --> 00:42:40,550  
to get about the it's a funny irony

1031  
00:42:38,960 --> 00:42:43,210  
actually you know because we have big

1032  
00:42:40,550 --> 00:42:45,769  
telescopes and they're expensive

1033  
00:42:43,210 --> 00:42:47,360  
instruments but you know obviously I

1034  
00:42:45,769 --> 00:42:48,860  
think totally worth it because of all

1035  
00:42:47,360 --> 00:42:50,780  
this stuff that we learn about them so

1036  
00:42:48,860 --> 00:42:52,910  
we put our best instruments our best

1037  
00:42:50,780 --> 00:42:54,680  
cameras or best spectrographs on those

1038  
00:42:52,909 --> 00:42:56,539  
biggest telescopes and if we have a

1039  
00:42:54,679 --> 00:43:02,539  
supernova like the star Betelgeuse for

1040  
00:42:56,539 --> 00:43:04,670  
example it's do they float right you

1041  
00:43:02,539 --> 00:43:06,050  
wouldn't be any of our great telescopes

1042  
00:43:04,670 --> 00:43:07,519  
it would be too bright for those tools

1043  
00:43:06,050 --> 00:43:09,440  
that's right and we'd all have to break

1044  
00:43:07,519 --> 00:43:12,349  
out our celeste ron's and our you know

1045  
00:43:09,440 --> 00:43:15,349  
our binoculars and our eyeballs and try

1046  
00:43:12,349 --> 00:43:16,909  
and learn that way so I'm glad you

1047  
00:43:15,349 --> 00:43:18,829  
brought that up I'm glad you brought

1048  
00:43:16,909 --> 00:43:22,059  
that up because my next question before

1049  
00:43:18,829 --> 00:43:25,549  
I start going to some other comments is

1050  
00:43:22,059 --> 00:43:27,650  
are we in danger is earth or is this as

1051  
00:43:25,550 --> 00:43:29,750  
our solar system or Betelgeuse goes

1052  
00:43:27,650 --> 00:43:32,930  
what's gonna do we have to worry about

1053  
00:43:29,750 --> 00:43:34,489  
supernovae probably not so I packed at

1054  
00:43:32,929 --> 00:43:38,059  
Rutgers a couple years ago I taught a

1055

00:43:34,489 --> 00:43:43,489  
seminar called death from the skies by

1056  
00:43:38,059 --> 00:43:45,710  
somebody too as the textbook for that

1057  
00:43:43,489 --> 00:43:48,319  
class for that seminar and for a

1058  
00:43:45,710 --> 00:43:50,420  
supernova it turns out we're not any of

1059  
00:43:48,320 --> 00:43:51,380  
the stars nearby they're massive enough

1060  
00:43:50,420 --> 00:43:54,050  
that are likely to become a supernova

1061  
00:43:51,380 --> 00:43:56,059  
are not near enough to really affect us

1062  
00:43:54,050 --> 00:43:57,980  
a supernova would have to be pretty

1063  
00:43:56,059 --> 00:44:02,090  
close within just a few light years to

1064  
00:43:57,980 --> 00:44:03,530  
pose a serious problem so so right now

1065  
00:44:02,090 --> 00:44:04,850  
we're not in danger however there is

1066  
00:44:03,530 --> 00:44:06,860  
evidence on the earth that there have

1067  
00:44:04,849 --> 00:44:08,690  
been nearby supernovae where the earth

1068  
00:44:06,860 --> 00:44:10,970  
and the Sun were just near a massive

1069  
00:44:08,690 --> 00:44:12,980

star at a previous time in the history

1070

00:44:10,969 --> 00:44:15,379

of our orbit around the galaxy where

1071

00:44:12,980 --> 00:44:16,550

there that did happen so you know we

1072

00:44:15,380 --> 00:44:18,740

don't have to worry right now but maybe

1073

00:44:16,550 --> 00:44:20,030

look so what keeps me up at night or

1074

00:44:18,739 --> 00:44:20,779

gamma-ray bursts but that's another

1075

00:44:20,030 --> 00:44:22,640

topic I

1076

00:44:20,780 --> 00:44:23,930

I would like to we should have it we

1077

00:44:22,639 --> 00:44:27,500

should have a hangout all that to Carol

1078

00:44:23,929 --> 00:44:32,059

a death in the skies or something we can

1079

00:44:27,500 --> 00:44:33,650

die okay so Charles Bell is asking and

1080

00:44:32,059 --> 00:44:35,690

this is a good segue into the next thing

1081

00:44:33,650 --> 00:44:37,760

I want to talk about on the Google+

1082

00:44:35,690 --> 00:44:39,920

event page he's asking is there a

1083

00:44:37,760 --> 00:44:42,560

pipeline process to check new images

1084  
00:44:39,920 --> 00:44:44,960  
taken by Hubble for supernovae in any

1085  
00:44:42,559 --> 00:44:46,400  
galaxies in the field of view and let me

1086  
00:44:44,960 --> 00:44:49,190  
ask that question another way how does

1087  
00:44:46,400 --> 00:44:51,349  
Hubble discover supernovas because the

1088  
00:44:49,190 --> 00:44:53,329  
second question is have any supernovae

1089  
00:44:51,349 --> 00:44:57,409  
been discovered by Hubble the short

1090  
00:44:53,329 --> 00:44:59,179  
answer is yes but maybe maybe Carol you

1091  
00:44:57,409 --> 00:45:01,639  
make you comment on that a little bit

1092  
00:44:59,179 --> 00:45:04,690  
some of the the ways in which Hubble

1093  
00:45:01,639 --> 00:45:08,299  
look at the sky that to find supernovae

1094  
00:45:04,690 --> 00:45:10,610  
well also I think also Saab can probably

1095  
00:45:08,300 --> 00:45:14,120  
address this as well but there is a

1096  
00:45:10,610 --> 00:45:16,250  
campaign now ever since you know this

1097  
00:45:14,119 --> 00:45:19,009  
early work on the expansion of the

1098  
00:45:16,250 --> 00:45:23,150  
universe where there's a number of

1099  
00:45:19,010 --> 00:45:26,300  
things if there are if somebody else

1100  
00:45:23,150 --> 00:45:29,360  
discovers a supernova the there are

1101  
00:45:26,300 --> 00:45:33,710  
observers that can ask the director to

1102  
00:45:29,360 --> 00:45:35,660  
immediately look at that object and take

1103  
00:45:33,710 --> 00:45:38,829  
a series of observations with the Hubble

1104  
00:45:35,659 --> 00:45:43,730  
Space Telescope there's also a campaign

1105  
00:45:38,829 --> 00:45:48,349  
for observations that are taken by other

1106  
00:45:43,730 --> 00:45:50,300  
observers at distant galaxies to comb

1107  
00:45:48,349 --> 00:45:54,049  
through that data to look for so

1108  
00:45:50,300 --> 00:45:55,460  
supernovae so there's not there are

1109  
00:45:54,050 --> 00:45:57,710  
other telescopes that look for

1110  
00:45:55,460 --> 00:46:00,349  
supernovae in particular and asteroids

1111  
00:45:57,710 --> 00:46:02,630  
and all kinds of things Hubble does not

1112

00:46:00,349 --> 00:46:04,250  
have a campaign specifically where you

1113  
00:46:02,630 --> 00:46:06,380  
just point in the sky and hope there's a

1114  
00:46:04,250 --> 00:46:08,900  
supernova but observations that are

1115  
00:46:06,380 --> 00:46:12,769  
being used for something else are then

1116  
00:46:08,900 --> 00:46:15,349  
examined to see if there are supernovae

1117  
00:46:12,769 --> 00:46:17,000  
that events and if they find them fast

1118  
00:46:15,349 --> 00:46:18,799  
enough they can go back and observe

1119  
00:46:17,000 --> 00:46:19,639  
either with Hubble or another

1120  
00:46:18,800 --> 00:46:21,890  
observatory

1121  
00:46:19,639 --> 00:46:24,079  
so do you wanna elaborate on that little

1122  
00:46:21,889 --> 00:46:25,909  
sure yeah so what we often call these

1123  
00:46:24,079 --> 00:46:27,769  
supernovae searches piggybacking on

1124  
00:46:25,909 --> 00:46:30,409  
other people's search so you might have

1125  
00:46:27,769 --> 00:46:32,389  
seen these iconic images from Hubble

1126  
00:46:30,409 --> 00:46:34,579

like the Deep Field and the Ultra Deep

1127

00:46:32,389 --> 00:46:36,529

Field and the way they take those images

1128

00:46:34,579 --> 00:46:38,449

is that Hubble has to point at one small

1129

00:46:36,530 --> 00:46:41,900

patch of the sky for a long time for

1130

00:46:38,449 --> 00:46:43,819

hours or days and so you could do that

1131

00:46:41,900 --> 00:46:45,440

you could just point it at for a few

1132

00:46:43,820 --> 00:46:47,120

days at the same patch on the sky and

1133

00:46:45,440 --> 00:46:49,340

then just say okay here's my great image

1134

00:46:47,119 --> 00:46:51,650

but what the supernova folks likes to do

1135

00:46:49,340 --> 00:46:53,960

is say hey why don't you slow down a

1136

00:46:51,650 --> 00:46:56,059

little bit and spread that time out over

1137

00:46:53,960 --> 00:46:57,920

a few months and so instead of observing

1138

00:46:56,059 --> 00:46:59,900

all at once take one image and then come

1139

00:46:57,920 --> 00:47:02,630

back later a month later and then again

1140

00:46:59,900 --> 00:47:03,590

another month in the end after you know



1141  
00:47:02,630 --> 00:47:05,269  
a certain amount of time you'll have

1142  
00:47:03,590 --> 00:47:06,950  
your full data set that you can add

1143  
00:47:05,269 --> 00:47:08,719  
together and make your beautiful Deep

1144  
00:47:06,949 --> 00:47:10,669  
Field but in the meantime we'll be able

1145  
00:47:08,719 --> 00:47:12,980  
to look at each month and say hey was

1146  
00:47:10,670 --> 00:47:14,990  
there a new object there a new supernova

1147  
00:47:12,980 --> 00:47:16,730  
that went off in in between and so

1148  
00:47:14,989 --> 00:47:19,339  
that's what we do we piggyback on these

1149  
00:47:16,730 --> 00:47:22,429  
big surveys like candles and clash and

1150  
00:47:19,340 --> 00:47:24,769  
now the frontier fields to use Hubble to

1151  
00:47:22,429 --> 00:47:27,319  
find supernovae and the reason we want

1152  
00:47:24,769 --> 00:47:29,150  
Hubble to find two novae yes many people

1153  
00:47:27,320 --> 00:47:30,530  
can find them from the ground and even

1154  
00:47:29,150 --> 00:47:31,550  
amateur astronomers find supernovae

1155  
00:47:30,530 --> 00:47:34,640  
which is I think a really fascinating

1156  
00:47:31,550 --> 00:47:36,050  
part of this science topic but Hubble is

1157  
00:47:34,639 --> 00:47:38,299  
the only thing that can find a really

1158  
00:47:36,050 --> 00:47:39,950  
really distant one the ones that are ten

1159  
00:47:38,300 --> 00:47:41,420  
billion light-years away and we want to

1160  
00:47:39,949 --> 00:47:43,339  
know what the universe was like all the

1161  
00:47:41,420 --> 00:47:44,809  
way back then and so Hubble is really

1162  
00:47:43,340 --> 00:47:47,120  
key at finding the most distant

1163  
00:47:44,809 --> 00:47:49,489  
supernovae and we love to use public to

1164  
00:47:47,119 --> 00:47:52,009  
find mine so I was gonna comment because

1165  
00:47:49,489 --> 00:47:54,699  
I think Tony you mentioned it before at

1166  
00:47:52,010 --> 00:47:58,100  
some point that in the frontier fields

1167  
00:47:54,699 --> 00:48:00,739  
which are deep observations that are

1168  
00:47:58,099 --> 00:48:03,289  
being taken over a three-year period of

1169

00:48:00,739 --> 00:48:07,129  
six clusters and we've talked about that

1170  
00:48:03,289 --> 00:48:10,300  
on hangouts before and just as sirup

1171  
00:48:07,130 --> 00:48:14,720  
said the the observations are

1172  
00:48:10,300 --> 00:48:17,900  
interspersed and and also you don't want

1173  
00:48:14,719 --> 00:48:19,909  
to dominate the just with one program so

1174  
00:48:17,900 --> 00:48:21,740  
other programs are fitting in between

1175  
00:48:19,909 --> 00:48:23,500  
this and very early in the frontier

1176  
00:48:21,739 --> 00:48:26,839  
fields one of the first frontier fields

1177  
00:48:23,500 --> 00:48:29,239  
observed there was a supernova and it is

1178  
00:48:26,840 --> 00:48:31,220  
likely over a three-year period that

1179  
00:48:29,239 --> 00:48:34,099  
those fields because those observations

1180  
00:48:31,219 --> 00:48:36,589  
are spread out for so long that other

1181  
00:48:34,099 --> 00:48:38,059  
supernovae by the way I wanted to

1182  
00:48:36,590 --> 00:48:39,769  
mention other things of the question

1183  
00:48:38,059 --> 00:48:41,599

asked whether there was a pipeline to do

1184

00:48:39,769 --> 00:48:43,489

this and there is a pipeline on that

1185

00:48:41,599 --> 00:48:46,400

pipelines damage Curtis McCauley

1186

00:48:43,489 --> 00:48:47,629

among others Steve Rodman so we have

1187

00:48:46,400 --> 00:48:49,220

people and pretty

1188

00:48:47,630 --> 00:48:51,200

driving student with me at Rutgers and

1189

00:48:49,219 --> 00:48:53,089

when he was here he helped develop

1190

00:48:51,199 --> 00:48:54,889

pipeline that's now being used in the

1191

00:48:53,090 --> 00:48:56,870

frontier fields when the Hubble takes

1192

00:48:54,889 --> 00:48:59,690

you do you have to take that data match

1193

00:48:56,869 --> 00:49:01,549

it up data subtract it to the images to

1194

00:48:59,690 --> 00:49:03,950

look for anything new and often there's

1195

00:49:01,550 --> 00:49:05,450

a lot of stuff from you know a cosmic

1196

00:49:03,949 --> 00:49:07,159

ray that was one image that's not the

1197

00:49:05,449 --> 00:49:08,389

other and so Curtis developed some of

1198  
00:49:07,159 --> 00:49:10,489  
the tools some of the software that we

1199  
00:49:08,389 --> 00:49:16,519  
use to find what are the real new things

1200  
00:49:10,489 --> 00:49:18,229  
that real news producer right now I'm

1201  
00:49:16,519 --> 00:49:24,009  
telling Tony you put on headphones -

1202  
00:49:18,230 --> 00:49:24,010  
yeah sorry I'm doing thank you thank you

1203  
00:49:27,849 --> 00:49:41,929  
ok you can speak now well not until I

1204  
00:49:30,980 --> 00:49:44,599  
change it no it's worse what you just

1205  
00:49:41,929 --> 00:49:47,899  
did man you're on yeah your microphones

1206  
00:49:44,599 --> 00:49:53,929  
down but the echo is gone so which I

1207  
00:49:47,900 --> 00:49:57,309  
kind of like yeah no you're very faint

1208  
00:49:53,929 --> 00:49:57,309  
put the microphone in for your mouth

1209  
00:49:59,199 --> 00:50:02,719  
speak into the microphone Tony I'm

1210  
00:50:01,550 --> 00:50:04,580  
speaking into the microphone

1211  
00:50:02,719 --> 00:50:09,559  
no the microphone is far away from your

1212  
00:50:04,579 --> 00:50:12,369  
mouth is this better yeah yeah okay all

1213  
00:50:09,559 --> 00:50:15,739  
right now sorry about that folks

1214  
00:50:12,369 --> 00:50:17,480  
feedback okay

1215  
00:50:15,739 --> 00:50:18,829  
so they I don't know if this is going to

1216  
00:50:17,480 --> 00:50:20,780  
work or not but alais not if you could

1217  
00:50:18,829 --> 00:50:23,150  
put up the frontier fields thing on the

1218  
00:50:20,780 --> 00:50:24,380  
little new showcase app that they have

1219  
00:50:23,150 --> 00:50:26,240  
hopefully this will be something that

1220  
00:50:24,380 --> 00:50:29,570  
will illustrate what we were just

1221  
00:50:26,239 --> 00:50:31,969  
talking about it with the question of

1222  
00:50:29,570 --> 00:50:34,910  
have has Hubble discovered any

1223  
00:50:31,969 --> 00:50:36,409  
supernovae the answer is of course it's

1224  
00:50:34,909 --> 00:50:38,089  
discovered many and in fact with the

1225  
00:50:36,409 --> 00:50:39,500  
frontier fields initiative one of the

1226

00:50:38,090 --> 00:50:41,480  
things that does and one of the ways in

1227  
00:50:39,500 --> 00:50:43,880  
which supernovae are discovered is you

1228  
00:50:41,480 --> 00:50:45,110  
look at a patch of sky you take some

1229  
00:50:43,880 --> 00:50:46,880  
images and then you go back and you look

1230  
00:50:45,110 --> 00:50:48,140  
at it again and if there's any new stars

1231  
00:50:46,880 --> 00:50:49,940  
you'll know that hey there's you know

1232  
00:50:48,139 --> 00:50:51,650  
there must be that's a supernova going

1233  
00:50:49,940 --> 00:50:54,349  
there it's one of the triggers for for

1234  
00:50:51,650 --> 00:50:55,700  
having seen one and I think frontier

1235  
00:50:54,349 --> 00:50:57,199  
fields was under it was going for just a

1236  
00:50:55,699 --> 00:51:00,859  
few weeks and it had already discovered

1237  
00:50:57,199 --> 00:51:01,460  
its first its first supernova so this

1238  
00:51:00,860 --> 00:51:03,740  
one wasn't

1239  
00:51:01,460 --> 00:51:07,070  
right or anything but it was it was a

1240  
00:51:03,739 --> 00:51:08,899

discovery Curtis I may be off track here

1241

00:51:07,070 --> 00:51:10,580

with this question and I'm if I if I'm

1242

00:51:08,900 --> 00:51:14,900

asking the wrong person please let me

1243

00:51:10,579 --> 00:51:16,369

know but your organization LLC ODT do

1244

00:51:14,900 --> 00:51:19,519

you guys have any supernova surveys

1245

00:51:16,369 --> 00:51:21,260

ground-based surveys there so LC OTT is

1246

00:51:19,519 --> 00:51:25,070

actually designed to be more of a

1247

00:51:21,260 --> 00:51:25,550

follow-up machine kind of what I'm sorry

1248

00:51:25,070 --> 00:51:29,480

Carol

1249

00:51:25,550 --> 00:51:31,400

carol was saying earlier about where

1250

00:51:29,480 --> 00:51:32,900

somebody else discovers a supernova and

1251

00:51:31,400 --> 00:51:37,099

then we can simply turn one of our

1252

00:51:32,900 --> 00:51:39,710

telescopes and start observing it okay

1253

00:51:37,099 --> 00:51:41,180

all right so I there are surveys though

1254

00:51:39,710 --> 00:51:43,099

that look at large areas of the sky



1255  
00:51:41,179 --> 00:51:45,469  
multiple times a night or multiple times

1256  
00:51:43,099 --> 00:51:51,859  
over the course of some period to find

1257  
00:51:45,469 --> 00:51:54,649  
these these supernovae you know in big

1258  
00:51:51,858 --> 00:51:57,348  
areas so okay so I want to move on to

1259  
00:51:54,650 --> 00:51:59,480  
some of the particulars of some of your

1260  
00:51:57,349 --> 00:52:00,500  
work with Hubble so Rob you have

1261  
00:51:59,480 --> 00:52:03,170  
mentioned something that you had done

1262  
00:52:00,500 --> 00:52:04,219  
something with a zombie star with using

1263  
00:52:03,170 --> 00:52:05,630  
Hubble do you wanna talk about that a

1264  
00:52:04,219 --> 00:52:07,159  
little bit that's right yeah so actually

1265  
00:52:05,630 --> 00:52:10,059  
all three of us Ryan and Curtis and I

1266  
00:52:07,159 --> 00:52:12,529  
were working on this kind of object and

1267  
00:52:10,059 --> 00:52:13,789  
you know we talked about how type 1a

1268  
00:52:12,530 --> 00:52:16,609  
supernovae are so important for

1269  
00:52:13,789 --> 00:52:18,199  
cosmology and yet Ryan said well here

1270  
00:52:16,608 --> 00:52:20,150  
are two possible ways they might explode

1271  
00:52:18,199 --> 00:52:22,489  
one was with two white dwarfs that

1272  
00:52:20,150 --> 00:52:24,950  
merged together to explode and one was

1273  
00:52:22,489 --> 00:52:26,838  
material from a normal star being dumped

1274  
00:52:24,949 --> 00:52:28,789  
onto a white dwarf who exploded and so

1275  
00:52:26,838 --> 00:52:30,469  
you would think that hey that's a big

1276  
00:52:28,789 --> 00:52:34,039  
difference whether you have to like you

1277  
00:52:30,469 --> 00:52:35,629  
know like worth merging or not and yet

1278  
00:52:34,039 --> 00:52:37,550  
you these are the same objects that you

1279  
00:52:35,630 --> 00:52:39,170  
use to measure the accelerating universe

1280  
00:52:37,550 --> 00:52:40,310  
and you know carol was asking doesn't

1281  
00:52:39,170 --> 00:52:42,200  
that make you uncomfortable that you

1282  
00:52:40,309 --> 00:52:45,400  
don't really know exactly how they

1283

00:52:42,199 --> 00:52:45,399  
explode and it does

1284  
00:52:45,449 --> 00:52:49,379  
but in some art from the cosmology

1285  
00:52:47,280 --> 00:52:51,180  
application of these type 1 days is what

1286  
00:52:49,380 --> 00:52:53,039  
are they and so for a while we've been

1287  
00:52:51,179 --> 00:52:55,949  
trying to attack this question with you

1288  
00:52:53,039 --> 00:52:57,509  
know lots of people have have and one of

1289  
00:52:55,949 --> 00:52:58,889  
the things we like to do because I don't

1290  
00:52:57,510 --> 00:53:01,230  
know maybe we're kind of weird people

1291  
00:52:58,889 --> 00:53:03,509  
but we like to look at the weirdo type

1292  
00:53:01,230 --> 00:53:05,039  
one A's so every so often we get a type

1293  
00:53:03,510 --> 00:53:07,619  
1a or something that looks like a type

1294  
00:53:05,039 --> 00:53:09,239  
1a but isn't the same luminosity it's

1295  
00:53:07,619 --> 00:53:10,858  
somewhat different so there are a few

1296  
00:53:09,239 --> 00:53:12,059  
that are a little too bright and then

1297  
00:53:10,858 --> 00:53:13,199

there are a few that are too faint and

1298

00:53:12,059 --> 00:53:15,358

we've been studying the ones that are

1299

00:53:13,199 --> 00:53:17,699

too faint and we still think that these

1300

00:53:15,358 --> 00:53:18,779

are the these morph explosions Ryan came

1301

00:53:17,699 --> 00:53:22,230

up with a great name for them we call

1302

00:53:18,780 --> 00:53:25,290

them type 1a X supernovae and the X is

1303

00:53:22,230 --> 00:53:27,210

mysterious and it also harkens back to

1304

00:53:25,289 --> 00:53:29,608

the first one that we identified of this

1305

00:53:27,210 --> 00:53:33,389

class which was a supernova called 2002

1306

00:53:29,608 --> 00:53:35,130

CX and so the idea is if we can study

1307

00:53:33,389 --> 00:53:37,230

these weirdos and what makes them

1308

00:53:35,130 --> 00:53:39,059

different than normal type 1a s we might

1309

00:53:37,230 --> 00:53:40,800

understand how all the weirdos come from

1310

00:53:39,059 --> 00:53:42,420

this kind of star and all the normals

1311

00:53:40,800 --> 00:53:43,530

come from two white dwarfs merging or

1312  
00:53:42,420 --> 00:53:45,389  
whatever the case may be

1313  
00:53:43,530 --> 00:53:46,440  
and so we've been studying these weirdos

1314  
00:53:45,389 --> 00:53:48,118  
and one of the things we would like to

1315  
00:53:46,440 --> 00:53:51,539  
do with the weirdos there was one in

1316  
00:53:48,119 --> 00:53:53,280  
2012 called 2012 Z and it was a great

1317  
00:53:51,539 --> 00:53:55,980  
coincidence that that galaxy that it

1318  
00:53:53,280 --> 00:54:00,420  
went off in in NGC 1309 I don't know if

1319  
00:53:55,980 --> 00:54:03,568  
we have a picture of that I think for an

1320  
00:54:00,420 --> 00:54:05,608  
actor of 2012 Z so what we did is we

1321  
00:54:03,568 --> 00:54:07,889  
there was already and this is one of the

1322  
00:54:05,608 --> 00:54:10,170  
great things about Hubble is that

1323  
00:54:07,889 --> 00:54:12,239  
there's the Hubble archive so any

1324  
00:54:10,170 --> 00:54:14,519  
astronomer after the Hubble data has

1325  
00:54:12,239 --> 00:54:16,379  
been taken after a period of time easily

1326  
00:54:14,519 --> 00:54:18,358  
a year or so that did it becomes public

1327  
00:54:16,380 --> 00:54:21,450  
to the whole world and anyone can go

1328  
00:54:18,358 --> 00:54:24,119  
look to see what is in that data and so

1329  
00:54:21,449 --> 00:54:26,818  
this supernova went off in 2012 scary

1330  
00:54:24,119 --> 00:54:34,289  
isn't it now okay great and so that's

1331  
00:54:26,818 --> 00:54:35,940  
actually this is 2014 J yeah but so we

1332  
00:54:34,289 --> 00:54:38,429  
had the supernova in 2012 that went off

1333  
00:54:35,940 --> 00:54:41,010  
in this galaxy NGC 1309 this nice

1334  
00:54:38,429 --> 00:54:43,460  
beautiful spiral galaxy and there's a

1335  
00:54:41,010 --> 00:54:47,400  
little too inset boxes on the on the

1336  
00:54:43,460 --> 00:54:49,619  
link I sent anyway and what happened is

1337  
00:54:47,400 --> 00:54:51,960  
that one of our colleagues have actually

1338  
00:54:49,619 --> 00:54:56,250  
taken lots of images of that galaxy to

1339  
00:54:51,960 --> 00:54:57,358  
study the aftermath of 2002 so in the

1340

00:54:56,250 --> 00:54:59,340  
Hubble archive there were these great

1341  
00:54:57,358 --> 00:55:01,409  
images of this

1342  
00:54:59,340 --> 00:55:03,720  
this galaxy and what we could do is we

1343  
00:55:01,409 --> 00:55:06,000  
could go back and look to see what was

1344  
00:55:03,719 --> 00:55:08,099  
at the position there it is so there's

1345  
00:55:06,000 --> 00:55:12,239  
that beautiful galaxy on the left and

1346  
00:55:08,099 --> 00:55:14,219  
then on the right so if we zoom in on

1347  
00:55:12,239 --> 00:55:18,659  
the location of the new supernova in

1348  
00:55:14,219 --> 00:55:20,699  
2012 on the right what we found and

1349  
00:55:18,659 --> 00:55:22,710  
actually this was a really June work of

1350  
00:55:20,699 --> 00:55:24,179  
Curtis who took all that old data and

1351  
00:55:22,710 --> 00:55:27,119  
combined them together in a really

1352  
00:55:24,179 --> 00:55:29,879  
optimal way to make all the the stars as

1353  
00:55:27,119 --> 00:55:31,500  
sharp as possible so on the lower right

1354  
00:55:29,880 --> 00:55:33,420

you see the position of the supernovae

1355

00:55:31,500 --> 00:55:34,920

which went off in 2012 the image is

1356

00:55:33,420 --> 00:55:36,720

actually from 2013 when the supernova

1357

00:55:34,920 --> 00:55:39,300

was faint enough that it we could get a

1358

00:55:36,719 --> 00:55:41,639

good image with Hubble and then on the

1359

00:55:39,300 --> 00:55:43,860

upper part is the data from 2005 and

1360

00:55:41,639 --> 00:55:46,559

2006 before the supernova went off and

1361

00:55:43,860 --> 00:55:48,780

what we found for this weirdo white

1362

00:55:46,559 --> 00:55:50,369

dwarf supernova this type 1 ax that we

1363

00:55:48,780 --> 00:55:52,620

call is that there was actually

1364

00:55:50,369 --> 00:55:54,869

something there where that arrow s1

1365

00:55:52,619 --> 00:55:56,730

points to a little blue smudge now that

1366

00:55:54,869 --> 00:55:58,980

probably doesn't look like much to the

1367

00:55:56,730 --> 00:56:01,679

viewers but when Curtis showed me and

1368

00:55:58,980 --> 00:56:03,360

Ryan that we were ecstatic you know I'll



1369  
00:56:01,679 --> 00:56:04,619  
let them tell you about what their field

1370  
00:56:03,360 --> 00:56:07,019  
their feelings were when they when we

1371  
00:56:04,619 --> 00:56:09,210  
made this discovery but the idea that

1372  
00:56:07,019 --> 00:56:11,489  
for a white dwarf supernova where people

1373  
00:56:09,210 --> 00:56:13,260  
have been looking to see a progenitor

1374  
00:56:11,489 --> 00:56:15,599  
the star that exploded before a white

1375  
00:56:13,260 --> 00:56:17,700  
dwarf supernova for a long time and they

1376  
00:56:15,599 --> 00:56:19,469  
never did and so that actually led a lot

1377  
00:56:17,699 --> 00:56:21,149  
of people to think that most of these

1378  
00:56:19,469 --> 00:56:22,889  
white dwarf supernovae came from - white

1379  
00:56:21,150 --> 00:56:24,180  
dwarfs merging where the white dwarfs

1380  
00:56:22,889 --> 00:56:26,190  
would be too faint to see that's why we

1381  
00:56:24,179 --> 00:56:29,149  
never saw them but in this case in this

1382  
00:56:26,190 --> 00:56:31,380  
weirdo case we did see something and so

1383  
00:56:29,150 --> 00:56:33,599  
we wrote a whole paper on it it was in

1384  
00:56:31,380 --> 00:56:36,570  
nature and we did a little press release

1385  
00:56:33,599 --> 00:56:39,509  
and I don't know who was maybe Carol had

1386  
00:56:36,570 --> 00:56:41,070  
a hand in it but someone knows so we

1387  
00:56:39,510 --> 00:56:43,110  
talked about well this is this dead star

1388  
00:56:41,070 --> 00:56:44,640  
this white dwarf but it sort of got

1389  
00:56:43,110 --> 00:56:46,680  
resurrected when it got this material

1390  
00:56:44,639 --> 00:56:49,259  
transferred onto it from this blue

1391  
00:56:46,679 --> 00:56:50,669  
companion that we're seeing and so well

1392  
00:56:49,260 --> 00:56:52,530  
that sounds like a zombie you know and

1393  
00:56:50,670 --> 00:56:54,210  
so we called it a zombie star and we you

1394  
00:56:52,530 --> 00:56:55,560  
know we went with that and the news

1395  
00:56:54,210 --> 00:56:57,210  
loved that so there were lots of news

1396  
00:56:55,559 --> 00:56:58,860  
articles about this zombie star that we

1397

00:56:57,210 --> 00:57:00,240  
discovered and really the important

1398  
00:56:58,860 --> 00:57:01,829  
thing is that you know is the first time

1399  
00:57:00,239 --> 00:57:03,509  
for a white dwarf supernova we got to

1400  
00:57:01,829 --> 00:57:06,420  
see what was there before and we

1401  
00:57:03,510 --> 00:57:08,700  
actually saw something great so we are

1402  
00:57:06,420 --> 00:57:12,510  
almost out of time boys has gone by fast

1403  
00:57:08,699 --> 00:57:14,460  
I had a lot more point out that

1404  
00:57:12,510 --> 00:57:16,890  
ah nummy that has not changed since the

1405  
00:57:14,460 --> 00:57:19,349  
first person who called him or herself

1406  
00:57:16,889 --> 00:57:23,549  
an astronomer looked up and named a star

1407  
00:57:19,349 --> 00:57:27,809  
is that we name things any which way we

1408  
00:57:23,550 --> 00:57:31,230  
want and that's why we have lots of

1409  
00:57:27,809 --> 00:57:33,269  
weird names of objects you know I always

1410  
00:57:31,230 --> 00:57:35,130  
thought it was the zombie star because

1411  
00:57:33,269 --> 00:57:37,650

I'm seeing the supernova remnants and

1412

00:57:35,130 --> 00:57:40,230

they kind of look like brains and I just

1413

00:57:37,650 --> 00:57:43,230

you know like oh I see why they're

1414

00:57:40,230 --> 00:57:44,730

zombies stars I see what you want to see

1415

00:57:43,230 --> 00:57:45,929

in them I think they're like Rorschach

1416

00:57:44,730 --> 00:57:49,199

tests so maybe it's telling me more

1417

00:57:45,929 --> 00:57:50,339

about you and well honestly I think they

1418

00:57:49,199 --> 00:57:53,460

look like Metroid's

1419

00:57:50,340 --> 00:57:57,300

that's like the old-school gamer in me

1420

00:57:53,460 --> 00:57:58,860

oh my goodness okay so let's get to one

1421

00:57:57,300 --> 00:58:01,050

question before we have to go this is

1422

00:57:58,860 --> 00:58:03,570

from the Q&A app Shane Taylor is asking

1423

00:58:01,050 --> 00:58:06,600

may the variation of brightness between

1424

00:58:03,570 --> 00:58:09,150

type 1a supernovae be the difference

1425

00:58:06,599 --> 00:58:11,819

between what type of stars caused it a

1426  
00:58:09,150 --> 00:58:13,200  
white dwarf type 1a supernovae throws

1427  
00:58:11,820 --> 00:58:14,820  
off a specific type of brightness

1428  
00:58:13,199 --> 00:58:16,829  
compared to a type 1a triggered

1429  
00:58:14,820 --> 00:58:17,300  
supernova by a merging of two neutron

1430  
00:58:16,829 --> 00:58:20,099  
stars

1431  
00:58:17,300 --> 00:58:22,850  
so let me parse that a little bit may

1432  
00:58:20,099 --> 00:58:24,779  
the variation brightness between the

1433  
00:58:22,849 --> 00:58:26,039  
first of all is there much of a

1434  
00:58:24,780 --> 00:58:27,870  
variation in brightness between the

1435  
00:58:26,039 --> 00:58:29,070  
different types of type 1a supernovae

1436  
00:58:27,869 --> 00:58:32,190  
they're pretty much all the same that's

1437  
00:58:29,070 --> 00:58:34,650  
the point right so I'll handle this

1438  
00:58:32,190 --> 00:58:36,780  
because I've done a little bit of work

1439  
00:58:34,650 --> 00:58:38,910  
on this so first of all we for one age

1440  
00:58:36,780 --> 00:58:40,530  
we don't know what creates them we don't

1441  
00:58:38,909 --> 00:58:42,119  
know if it's the merger of two white

1442  
00:58:40,530 --> 00:58:43,850  
dwarfs the question you know says the

1443  
00:58:42,119 --> 00:58:46,769  
neutron stars but we know it's not that

1444  
00:58:43,849 --> 00:58:48,210  
it could be the merger of two white

1445  
00:58:46,769 --> 00:58:50,369  
dwarfs or it could be this white dwarf

1446  
00:58:48,210 --> 00:58:52,740  
that gets material from another star and

1447  
00:58:50,369 --> 00:58:55,980  
we don't know it could be one or the

1448  
00:58:52,739 --> 00:58:58,799  
other or some combination of both the

1449  
00:58:55,980 --> 00:59:01,740  
one the one observation that we have

1450  
00:58:58,800 --> 00:59:04,230  
that show some difference between

1451  
00:59:01,739 --> 00:59:08,669  
progenitor systems and this is not in

1452  
00:59:04,230 --> 00:59:11,880  
terms of of the the companion star as

1453  
00:59:08,670 --> 00:59:14,250  
necessarily but we're able to detect if

1454

00:59:11,880 --> 00:59:17,190  
there's outflowing material in the

1455  
00:59:14,250 --> 00:59:19,079  
circumstellar system so we can figure

1456  
00:59:17,190 --> 00:59:21,780  
out if there is some sort of wind coming

1457  
00:59:19,079 --> 00:59:24,269  
off of either an accretion disk or or

1458  
00:59:21,780 --> 00:59:26,430  
the the companion star or something like

1459  
00:59:24,269 --> 00:59:28,920  
that and we can say that some

1460  
00:59:26,429 --> 00:59:31,529  
I seem to have that and some do not some

1461  
00:59:28,920 --> 00:59:34,800  
you know stars that end up becoming a

1462  
00:59:31,530 --> 00:59:36,720  
type 1a supernovae and if you if you

1463  
00:59:34,800 --> 00:59:39,030  
separate those two classes those that

1464  
00:59:36,719 --> 00:59:41,279  
have these outflows and those that don't

1465  
00:59:39,030 --> 00:59:42,690  
there are luminosities we still have not

1466  
00:59:41,280 --> 00:59:46,859  
been able to say that they're different

1467  
00:59:42,690 --> 00:59:48,659  
but we can say that the velocity at

1468  
00:59:46,858 --> 00:59:51,058

which you know the material is expelled

1469

00:59:48,659 --> 00:59:53,909  
is slightly different for those two

1470

00:59:51,059 --> 00:59:56,579  
systems but that's the only observation

1471

00:59:53,909 --> 00:59:59,578  
yet that we have for the progenitor

1472

00:59:56,579 --> 01:00:02,220  
systems themselves now we have made

1473

00:59:59,579 --> 01:00:04,800  
other comparisons at sort of like bulk

1474

01:00:02,219 --> 01:00:06,209  
properties of the galaxy so we know for

1475

01:00:04,800 --> 01:00:09,269  
instance type 1a supernovae that come

1476

01:00:06,210 --> 01:00:11,579  
from big elliptical galaxies they tend

1477

01:00:09,269 --> 01:00:14,369  
to be fainter intrinsically than the

1478

01:00:11,579 --> 01:00:16,050  
ones that come from spiral galaxies but

1479

01:00:14,369 --> 01:00:17,818  
we correct for that because of this this

1480

01:00:16,050 --> 01:00:19,500  
light curve thing that's rob was talking

1481

01:00:17,818 --> 01:00:20,699  
about before and if you make that

1482

01:00:19,500 --> 01:00:23,489  
correction then there's there's no



1483  
01:00:20,699 --> 01:00:25,409  
difference that it's really it's a great

1484  
01:00:23,489 --> 01:00:27,088  
question because that's exactly what you

1485  
01:00:25,409 --> 01:00:29,308  
would think the different progenitor is

1486  
01:00:27,088 --> 01:00:30,989  
should lead to different kinds of

1487  
01:00:29,309 --> 01:00:32,730  
supernovae even slightly different maybe

1488  
01:00:30,989 --> 01:00:35,338  
the two white dwarfs would be slightly

1489  
01:00:32,730 --> 01:00:36,960  
brighter or fainter and so the the

1490  
01:00:35,338 --> 01:00:38,699  
question that's that the the question

1491  
01:00:36,960 --> 01:00:40,740  
are asked I mean that's exactly the kind

1492  
01:00:38,699 --> 01:00:42,358  
of hypotheses that a scientists we kind

1493  
01:00:40,739 --> 01:00:44,068  
of formulated and we're like okay let's

1494  
01:00:42,358 --> 01:00:45,358  
try and look and let's say let's see if

1495  
01:00:44,068 --> 01:00:46,769  
we can tell the difference in the

1496  
01:00:45,358 --> 01:00:48,630  
brightness if they come from this kind

1497  
01:00:46,769 --> 01:00:50,099  
of galaxies or if they're really young

1498  
01:00:48,630 --> 01:00:52,019  
or they're really old or something like

1499  
01:00:50,099 --> 01:00:54,390  
that and the really surprising thing is

1500  
01:00:52,019 --> 01:00:57,210  
that the 1a s are very similar there is

1501  
01:00:54,389 --> 01:01:00,469  
some range but it it seems me somehow

1502  
01:00:57,210 --> 01:01:03,809  
nature no matter what the inputs were a

1503  
01:01:00,469 --> 01:01:05,129  
writer used a great analogy and Nadia

1504  
01:01:03,809 --> 01:01:07,230  
Drake in an article that she wrote about

1505  
01:01:05,130 --> 01:01:09,450  
type 1a supernovae you have different

1506  
01:01:07,230 --> 01:01:11,219  
ingredients in different recipes and yet

1507  
01:01:09,449 --> 01:01:13,199  
the final product turns out the same so

1508  
01:01:11,219 --> 01:01:14,548  
that somehow nature does that we're

1509  
01:01:13,199 --> 01:01:16,500  
trying to figure out why that is oh

1510  
01:01:14,548 --> 01:01:17,940  
that's a great that's a great analogy

1511

01:01:16,500 --> 01:01:19,650  
okay well thank you should me for that

1512  
01:01:17,940 --> 01:01:21,329  
great question I'm afraid we're out of

1513  
01:01:19,650 --> 01:01:23,519  
time folks we're gonna have to stop here

1514  
01:01:21,329 --> 01:01:26,369  
I want to thank thank you guys sir Rob

1515  
01:01:23,519 --> 01:01:27,809  
and and Ryan and Curtis this has been an

1516  
01:01:26,369 --> 01:01:29,400  
awesome hangout thank you for taking

1517  
01:01:27,809 --> 01:01:31,890  
time out to talk about super novae with

1518  
01:01:29,400 --> 01:01:34,650  
us and next week folks we'll be back on

1519  
01:01:31,889 --> 01:01:38,338  
our regular time on Thursday 3:00 p.m.

1520  
01:01:34,650 --> 01:01:40,000  
Eastern 7:00 p.m. Greenwich Time where

1521  
01:01:38,338 --> 01:01:42,969  
we will be talking about

1522  
01:01:40,000 --> 01:01:45,369  
the plumes of Europa if you may remember

1523  
01:01:42,969 --> 01:01:48,009  
recently that we have did a press

1524  
01:01:45,369 --> 01:01:49,779  
release where there were some RIT some

1525  
01:01:48,010 --> 01:01:52,360

research done looking at Europa plumes

1526

01:01:49,780 --> 01:01:54,040

and so we'll have the scientists on hand

1527

01:01:52,360 --> 01:01:55,599

to discuss that so we'll hope you'll

1528

01:01:54,039 --> 01:01:56,889

join us I'll have the event up by

1529

01:01:55,599 --> 01:01:59,349

tomorrow so you guys can let us know

1530

01:01:56,889 --> 01:02:01,629

you're coming on behalf of Carroll and

1531

01:01:59,349 --> 01:02:04,960

coalition Scott Lewis my name is Tony

1532

01:02:01,630 --> 01:02:07,170

Darnell thank you all for watching thank

1533

01:02:04,960 --> 01:02:07,170

you