

1
00:00:00,000 --> 00:00:05,609
I am dr. Frank summers of the office of

2
00:00:01,919 --> 00:00:08,280
public outreach when you came in you got

3
00:00:05,609 --> 00:00:12,320
a brand new lithograph I hope you got a

4
00:00:08,279 --> 00:00:15,779
brand new lithograph of supernova 1987a

5
00:00:12,320 --> 00:00:18,929
and this is in particular discussing

6
00:00:15,779 --> 00:00:21,778
what supernova 1987a looks like thirty

7
00:00:18,929 --> 00:00:23,670
years after the explosion there's a lot

8
00:00:21,778 --> 00:00:26,070
of things that don't change in astronomy

9
00:00:23,670 --> 00:00:27,330
over the course of a lifetime supernovae

10
00:00:26,070 --> 00:00:29,849
they're one of the things that actually

11
00:00:27,329 --> 00:00:31,678
do change over course your lifetime flip

12
00:00:29,849 --> 00:00:33,359
over on the back and you can read some

13
00:00:31,678 --> 00:00:36,719
of the changes that we have learned and

14
00:00:33,359 --> 00:00:38,488
all we still have more cool stuff that

15
00:00:36,719 --> 00:00:41,420
we're going to learn from watching

16
00:00:38,488 --> 00:00:44,339
supernovae 1980s a develop it's just

17
00:00:41,420 --> 00:00:48,090
changed from one phase into the other

18
00:00:44,340 --> 00:00:50,039
phase in around 2016 so it's a cool time

19
00:00:48,090 --> 00:00:52,230
to be watching it and we'll continue to

20
00:00:50,039 --> 00:00:55,379
watch it as long as we have telescopes

21
00:00:52,229 --> 00:00:58,409
to look at it alright tonight's talk

22
00:00:55,378 --> 00:01:01,769
will be active luminous blue variables

23
00:00:58,409 --> 00:01:03,929
in the Large Magellanic Clouds it's a

24
00:01:01,770 --> 00:01:06,450
mouthful but no one will explain it in

25
00:01:03,929 --> 00:01:09,540
great detail for you tonight

26
00:01:06,450 --> 00:01:10,290
and next month we have a really really

27
00:01:09,540 --> 00:01:13,618
cool talk

28
00:01:10,290 --> 00:01:15,210
Cassini's grand finale at Saturn and

29

00:01:13,618 --> 00:01:17,150
I'll tell you just a little bit more

30
00:01:15,209 --> 00:01:18,298
about that during the news summary

31
00:01:17,150 --> 00:01:21,030
Bonnie

32
00:01:18,299 --> 00:01:22,070
is our Saturn and Saturn ring expert

33
00:01:21,030 --> 00:01:25,680
here in the building

34
00:01:22,069 --> 00:01:27,239
so I twisted her arm actually I gave her

35
00:01:25,680 --> 00:01:29,250
no choice I said look you've just got to

36
00:01:27,239 --> 00:01:31,319
do this and she was like yeah I guess I

37
00:01:29,250 --> 00:01:33,810
got to do it okay so we'll do that and

38
00:01:31,319 --> 00:01:35,609
then November and December haven't been

39
00:01:33,810 --> 00:01:37,049
scheduled because astronomers don't

40
00:01:35,609 --> 00:01:40,500
respond to their emails over the summer

41
00:01:37,049 --> 00:01:43,229
break I'm waiting seriously I waited

42
00:01:40,500 --> 00:01:44,728
until after Labor Day and now I'm

43
00:01:43,228 --> 00:01:46,828

sending out the email tomorrow and I'll

44

00:01:44,728 --> 00:01:50,399

have those and the rest of the schedule

45

00:01:46,828 --> 00:01:52,199

filled out relatively soon if you want

46

00:01:50,399 --> 00:01:54,750

to find out about what that schedule is

47

00:01:52,200 --> 00:01:56,399

you can go to our website use your

48

00:01:54,750 --> 00:01:58,618

favorite search engine and put in Hubble

49

00:01:56,399 --> 00:02:01,170

public talks and you'll find the

50

00:01:58,618 --> 00:02:03,269

upcoming lectures listed here you can

51

00:02:01,170 --> 00:02:05,849

also watch live here are the links to

52

00:02:03,269 --> 00:02:08,519

live webcasting the archives of the

53

00:02:05,849 --> 00:02:12,060

webcasting back to over 10 years of

54

00:02:08,520 --> 00:02:13,680

talks and you can sign up for the email

55

00:02:12,060 --> 00:02:16,620

announcements which will remind you

56

00:02:13,680 --> 00:02:19,739

each month of while who's who's talking

57

00:02:16,620 --> 00:02:22,170

alright as I said the announcements you

58
00:02:19,739 --> 00:02:25,170
can sign up at the website if you do not

59
00:02:22,169 --> 00:02:26,669
like going to websites and you want to

60
00:02:25,169 --> 00:02:30,479
just hand me a piece of paper with your

61
00:02:26,669 --> 00:02:32,250
email that also works as well if you

62
00:02:30,479 --> 00:02:35,699
have comments or questions just send

63
00:02:32,250 --> 00:02:40,459
them to public lecture at STScI edu and

64
00:02:35,699 --> 00:02:43,259
I were one of my colleagues will respond

65
00:02:40,459 --> 00:02:46,650
social media we have Facebook Twitter

66
00:02:43,259 --> 00:02:48,989
YouTube and Instagram channels that are

67
00:02:46,650 --> 00:02:51,959
officially supported and have regular

68
00:02:48,989 --> 00:02:53,938
posts on them we have my stuff which is

69
00:02:51,959 --> 00:02:57,359
my blog my facebook Google and Twitter

70
00:02:53,938 --> 00:02:58,650
which are not regularly updated I in

71
00:02:57,359 --> 00:03:00,209
particular the last month I've been

72
00:02:58,650 --> 00:03:03,539
traveling a lot I don't think I've put

73
00:03:00,209 --> 00:03:04,859
anything up in the last three weeks but

74
00:03:03,539 --> 00:03:07,289
I will make up for it this month

75
00:03:04,859 --> 00:03:10,799
probably as I start to get my Eclipse

76
00:03:07,289 --> 00:03:18,388
stuff put out there guess what

77
00:03:10,799 --> 00:03:20,099
there's no observing tonight but they

78
00:03:18,389 --> 00:03:23,579
have a Maryland Space Grant consortium

79
00:03:20,098 --> 00:03:27,500
has just redone their website and they

80
00:03:23,579 --> 00:03:30,930
have Observatory status right on their a

81
00:03:27,500 --> 00:03:33,750
page for the Morris W off it telescope

82
00:03:30,930 --> 00:03:36,299
so if you go to their mate page MD dot

83
00:03:33,750 --> 00:03:39,060
space grant org click on observing

84
00:03:36,299 --> 00:03:41,280
you'll get this page and it will tell

85
00:03:39,060 --> 00:03:42,150
you what the status is for this Friday

86

00:03:41,280 --> 00:03:46,408
September

87
00:03:42,150 --> 00:03:48,780
what does that say 8 yes and it says

88
00:03:46,408 --> 00:03:51,478
check back Friday at 5:00 p.m. to find

89
00:03:48,780 --> 00:03:53,609
out if the observatory will be open ok

90
00:03:51,479 --> 00:03:55,199
so the staff will update this at 5:00

91
00:03:53,609 --> 00:03:57,030
p.m. you can come in and you can

92
00:03:55,199 --> 00:03:58,859
actually do a longer observing session

93
00:03:57,030 --> 00:04:01,378
on the Friday nights then you get to do

94
00:03:58,859 --> 00:04:04,169
after this especially tonight since you

95
00:04:01,378 --> 00:04:06,388
won't be able to do it today ok all

96
00:04:04,169 --> 00:04:10,590
right now let's do our news from the

97
00:04:06,389 --> 00:04:14,549
universe for September 2017 anybody want

98
00:04:10,590 --> 00:04:17,959
to guess what the first story is it is

99
00:04:14,549 --> 00:04:21,989
of course the Eclipse o'rama

100
00:04:17,959 --> 00:04:25,228

so the question I most got was did you

101

00:04:21,988 --> 00:04:27,000

go on vacation to see the Eclipse and my

102

00:04:25,228 --> 00:04:29,189

answer was of course

103

00:04:27,000 --> 00:04:32,420

no I did not go on vacation to see the

104

00:04:29,189 --> 00:04:35,759

Eclipse I went on vacation to see

105

00:04:32,420 --> 00:04:39,540

Yellowstone National Park and answer the

106

00:04:35,759 --> 00:04:43,319

ultimate question of where does a 2000

107

00:04:39,540 --> 00:04:47,300

pound bison walk answer is of course

108

00:04:43,319 --> 00:04:50,639

everybody together anywhere he wants

109

00:04:47,300 --> 00:04:52,230

this guy here decided he was gonna walk

110

00:04:50,639 --> 00:04:55,050

across the street and right through the

111

00:04:52,230 --> 00:04:57,060

parking lot I mean in between cars in

112

00:04:55,050 --> 00:04:58,350

the parking lot he wasn't more than 20

113

00:04:57,060 --> 00:05:01,379

feet away

114

00:04:58,350 --> 00:05:05,370

we saw some moose there's a mother moose

115
00:05:01,379 --> 00:05:07,199
and her calf eating lunch in a pond this

116
00:05:05,370 --> 00:05:10,649
is the Grand Canyon of the Yellowstone

117
00:05:07,199 --> 00:05:14,250
the Lower Falls and we saw geysers

118
00:05:10,649 --> 00:05:15,629
geysers and more geysers we had a really

119
00:05:14,250 --> 00:05:18,120
great weekend actually we left the

120
00:05:15,629 --> 00:05:21,418
geysers to last and we just got like 10

121
00:05:18,120 --> 00:05:24,000
geysers in into great eruptions in two

122
00:05:21,418 --> 00:05:26,490
days and then of course my favorite

123
00:05:24,000 --> 00:05:30,509
which we saved really till till the last

124
00:05:26,490 --> 00:05:32,759
was Grand Prismatic spring how many of

125
00:05:30,509 --> 00:05:35,189
you seen this I mean it's just so

126
00:05:32,759 --> 00:05:37,769
Technicolor you really own even-even now

127
00:05:35,189 --> 00:05:39,620
you go what's that really yeah it really

128
00:05:37,769 --> 00:05:42,779
was really the colors really are real

129
00:05:39,620 --> 00:05:45,418
and so we had a fantastic vacation in

130
00:05:42,779 --> 00:05:48,719
Yellowstone because eclipses could be

131
00:05:45,418 --> 00:05:50,459
clouded out so on the way after after we

132
00:05:48,720 --> 00:05:54,030
finished our vacation Yellowstone we

133
00:05:50,459 --> 00:05:57,418
drop down into Idaho and it was totality

134
00:05:54,029 --> 00:06:01,079
or bust as we saw in this one car in

135
00:05:57,418 --> 00:06:04,109
Idaho we went to Rexburg Idaho and they

136
00:06:01,079 --> 00:06:07,199
threw a festival they had a hundred

137
00:06:04,110 --> 00:06:08,879
tents and vendors and food trucks they

138
00:06:07,199 --> 00:06:11,759
had they gave over their whole public

139
00:06:08,879 --> 00:06:13,939
park to camping they probably had 50 to

140
00:06:11,759 --> 00:06:18,209
100 people camping out for the weekend

141
00:06:13,939 --> 00:06:21,360
and the movie theaters were very very on

142
00:06:18,209 --> 00:06:23,159
the ball they put up signs like this 3d

143

00:06:21,360 --> 00:06:27,360
glasses that this theater are not safe

144
00:06:23,160 --> 00:06:29,669
for viewing the solar eclipse the

145
00:06:27,360 --> 00:06:32,040
mini-mart had an eclipse sale for the

146
00:06:29,668 --> 00:06:34,500
three days around the Eclipse I mean it

147
00:06:32,040 --> 00:06:37,620
was just fun to have people get involved

148
00:06:34,500 --> 00:06:39,538
in it and so I being my first total

149
00:06:37,620 --> 00:06:40,439
solar eclipse I've ever seen just sat

150
00:06:39,538 --> 00:06:43,378
back

151
00:06:40,439 --> 00:06:46,409
and did not use my 3d glasses I used my

152
00:06:43,379 --> 00:06:49,139
actual solar viewing glasses and sat

153
00:06:46,408 --> 00:06:51,538
back and enjoyed it I didn't take any

154
00:06:49,139 --> 00:06:55,019
photographs but my son used his iPhone

155
00:06:51,538 --> 00:06:56,488
and he got something like that ok so I

156
00:06:55,019 --> 00:06:59,788
thought it was AI was impressed like I

157
00:06:56,488 --> 00:07:02,188

didn't I didn't even try and he was able

158

00:06:59,788 --> 00:07:04,079

to get that with his iPhone fortunately

159

00:07:02,189 --> 00:07:06,479

and I knew there would be there are

160

00:07:04,079 --> 00:07:09,718

plenty others who got some really great

161

00:07:06,478 --> 00:07:13,468

pictures including our master image

162

00:07:09,718 --> 00:07:16,319

processor here at Hubbell Zolt lavey he

163

00:07:13,468 --> 00:07:18,360

was in Jackson Hole there was an art

164

00:07:16,319 --> 00:07:23,939

exhibit of some of his photographs there

165

00:07:18,360 --> 00:07:27,509

and he got pictures like that in that

166

00:07:23,939 --> 00:07:29,968

cool so that is the corona and all the

167

00:07:27,509 --> 00:07:33,408

details and the striations of the solar

168

00:07:29,968 --> 00:07:36,178

wind blowing out away from the Sun

169

00:07:33,408 --> 00:07:38,329

result is an accomplishment and this

170

00:07:36,178 --> 00:07:48,328

right here he says is the star regulus

171

00:07:38,329 --> 00:07:50,338

ok yes yes ok so you could see about I'd

172
00:07:48,329 --> 00:07:52,348
say 60 to 70 percent of the detail he

173
00:07:50,338 --> 00:07:55,019
shows here with the naked eye which was

174
00:07:52,348 --> 00:07:56,728
really cool ok because I as a

175
00:07:55,019 --> 00:07:59,309
professional astronomer had seen

176
00:07:56,728 --> 00:08:02,008
pictures like this and I'd never seen a

177
00:07:59,309 --> 00:08:03,869
total totality before and the amount of

178
00:08:02,009 --> 00:08:07,499
detail in the striations I could see was

179
00:08:03,869 --> 00:08:09,059
surprised me huh they didn't move they

180
00:08:07,499 --> 00:08:12,869
were pretty much much much much

181
00:08:09,059 --> 00:08:17,159
stationary yes that that's Regulus

182
00:08:12,869 --> 00:08:25,589
that's Regulus I could see about 10

183
00:08:17,158 --> 00:08:27,688
stars around this guy it was just all

184
00:08:25,588 --> 00:08:32,099
started cheering and clapping and

185
00:08:27,689 --> 00:08:34,189
applause I probably didn't know what to

186
00:08:32,099 --> 00:08:34,189
expect

187
00:08:37,219 --> 00:08:44,399
Wow people were just spinning around on

188
00:08:41,698 --> 00:08:45,319
a lot of crazy pretty minutes so two

189
00:08:44,399 --> 00:08:49,129
minutes of

190
00:08:45,320 --> 00:08:52,100
in Rexburg Seoul also got pictures of

191
00:08:49,129 --> 00:08:54,889
something called Baily's beads and the

192
00:08:52,100 --> 00:08:57,170
Providence's so actually this is a

193
00:08:54,889 --> 00:08:58,759
really cool pic you can see the

194
00:08:57,169 --> 00:09:01,069
prominence on the edge of the Sun and

195
00:08:58,759 --> 00:09:04,220
down here you can start to see some a

196
00:09:01,070 --> 00:09:07,459
little bit of beading along up in here I

197
00:09:04,220 --> 00:09:10,009
couldn't see any any detail like that I

198
00:09:07,458 --> 00:09:11,989
could see individual little dots just as

199
00:09:10,009 --> 00:09:15,889
you came in and out of it but it was

200

00:09:11,990 --> 00:09:27,980
very quick and then of course you get

201
00:09:15,889 --> 00:09:38,149
the big effect this was what I remember

202
00:09:27,980 --> 00:09:40,490
most was the the Quran but as it comes

203
00:09:38,149 --> 00:09:42,409
out you watch it you gonna watch this as

204
00:09:40,490 --> 00:09:52,698
long as possible and then it starts to

205
00:09:42,409 --> 00:09:55,129
be so that's really cool I think we got

206
00:09:52,698 --> 00:09:58,689
a lot of people in America to understand

207
00:09:55,129 --> 00:10:01,370
that is really interesting which means

208
00:09:58,690 --> 00:10:03,260
that the traffic which was horrible

209
00:10:01,370 --> 00:10:06,049
getting to Salt Lake City at this time

210
00:10:03,259 --> 00:10:10,100
will be even worse next time which is

211
00:10:06,049 --> 00:10:11,929
only seven years away April 8th 2024 we

212
00:10:10,100 --> 00:10:14,720
get another four minutes total solar

213
00:10:11,929 --> 00:10:17,689
eclipse passing the peak is somewhere

214
00:10:14,720 --> 00:10:20,870

down here in Mexico it goes through just

215

00:10:17,690 --> 00:10:23,389

go to passes Austin and San Antonio go

216

00:10:20,870 --> 00:10:27,669

straight over Dallas goes all the way up

217

00:10:23,389 --> 00:10:27,669

through the Northeast and goes out over

218

00:10:28,299 --> 00:10:42,609

at the intersection of the okay it's the

219

00:11:31,049 --> 00:11:34,139

[Music]

220

00:11:39,909 --> 00:11:46,819

there is another major event happening

221

00:11:43,519 --> 00:11:50,810

and this month in September is the

222

00:11:46,820 --> 00:11:56,180

Cassini climax Cassini was launched 20

223

00:11:50,809 --> 00:11:59,448

years ago almost 21 October 1997 it was

224

00:11:56,179 --> 00:12:03,828

launched and it will be crashing into

225

00:11:59,448 --> 00:12:05,990

Saturday September 15 2017 and the

226

00:12:03,828 --> 00:12:08,828

estimated signal loss will occur on

227

00:12:05,990 --> 00:12:08,829

Seneca before a

228

00:12:14,778 --> 00:12:21,629

okay all right you know if they think

229
00:12:18,320 --> 00:12:23,278
there's a tiny tiny chance it might get

230
00:12:21,629 --> 00:12:25,289
them some of us and if there's any

231
00:12:23,278 --> 00:12:26,960
prebiotic life on us all this we don't

232
00:12:25,289 --> 00:12:29,429
want to contaminate it or anything so

233
00:12:26,960 --> 00:12:31,950
like we did with other ones we're going

234
00:12:29,429 --> 00:12:35,699
to smash it crashing into the planet and

235
00:12:31,950 --> 00:12:39,330
we're gonna learn about the details of

236
00:12:35,700 --> 00:12:41,820
the planet because ask for the last

237
00:12:39,330 --> 00:12:45,889
three or four hours as it goes in we'll

238
00:12:41,820 --> 00:12:50,278
be doing a real-time data stream

239
00:12:45,889 --> 00:13:16,338
real-time data stream will be 27 per

240
00:12:50,278 --> 00:13:16,338
second it's by a beta of this next month

241
00:13:18,169 --> 00:13:22,889
publicizing you'll see all sorts of cool

242
00:13:20,700 --> 00:13:24,300
stuff about it over the month see a

243
00:13:22,889 --> 00:13:25,439
little bit and Bonnie will explain to

244
00:13:24,299 --> 00:13:30,269
you what it all means

245
00:13:25,440 --> 00:13:32,850
next month one science story here

246
00:13:30,269 --> 00:13:36,360
tonight it's called into the

247
00:13:32,850 --> 00:13:40,019
stratosphere exoplanet edition now

248
00:13:36,360 --> 00:13:42,750
Earth's atmosphere is second okay we

249
00:13:40,019 --> 00:13:44,129
live and do almost everything down here

250
00:13:42,750 --> 00:13:46,830
the bottom layer of the atmosphere

251
00:13:44,129 --> 00:13:48,179
called troposphere and in the

252
00:13:46,830 --> 00:13:50,070
troposphere this is that this is a

253
00:13:48,179 --> 00:13:52,829
graphic tenant river's altitude

254
00:13:50,070 --> 00:14:00,330
temperature goes down in the troposphere

255
00:13:52,830 --> 00:14:02,759
okay but at a certain point it actually

256
00:14:00,330 --> 00:14:05,278
turns over and starts to get warmer and

257

00:14:02,759 --> 00:14:07,950
that is the layer of the atmosphere

258
00:14:05,278 --> 00:14:10,439
called the stratosphere the point is is

259
00:14:07,950 --> 00:14:12,050
we're trapping greenhouse gases are

260
00:14:10,440 --> 00:14:15,839
trying to heat down in the troposphere

261
00:14:12,049 --> 00:14:17,199
but it's being heated by the UV light in

262
00:14:15,839 --> 00:14:19,570
the status fear

263
00:14:17,200 --> 00:14:21,370
okay and then it turns over again into

264
00:14:19,570 --> 00:14:24,460
the mesosphere turn over again to the

265
00:14:21,370 --> 00:14:25,960
thermosphere and really consider the top

266
00:14:24,460 --> 00:14:28,030
the atmosphere everything else off

267
00:14:25,960 --> 00:14:30,220
here's the exosphere which is of course

268
00:14:28,029 --> 00:14:31,959
where Hubble the Space Shuttle one of

269
00:14:30,220 --> 00:14:34,480
the International Space Station are okay

270
00:14:31,960 --> 00:14:36,550
so the point is is that we understand

271
00:14:34,480 --> 00:14:39,190

first atmosphere and it's got these

272

00:14:36,549 --> 00:14:42,039

temperature inversions what we would

273

00:14:39,190 --> 00:14:45,040

want to know is are such temperature

274

00:14:42,039 --> 00:14:47,949

inversions characteristic of planets

275

00:14:45,039 --> 00:14:50,709

around other stars we see this

276

00:14:47,950 --> 00:14:51,580

temperature inversion here what happens

277

00:14:50,710 --> 00:14:59,440

on other stars

278

00:14:51,580 --> 00:15:04,509

well Hubble has a spectrum of a planet

279

00:14:59,440 --> 00:15:06,760

called was 1:21 be okay and looking at

280

00:15:04,509 --> 00:15:09,100

that they're trying to determine does it

281

00:15:06,759 --> 00:15:12,189

have a stratosphere is the are the other

282

00:15:09,100 --> 00:15:14,769

layers warmer than the inner layers if

283

00:15:12,190 --> 00:15:17,110

the other layers are cooler then they

284

00:15:14,769 --> 00:15:19,269

will actually absorb light from the

285

00:15:17,110 --> 00:15:21,730

lower layers whereas if the outer layers

286
00:15:19,269 --> 00:15:24,069
are warmer then they will emit light

287
00:15:21,730 --> 00:15:27,340
okay so you've got two graphs here this

288
00:15:24,070 --> 00:15:30,250
is purple this is a spectrum for a brown

289
00:15:27,340 --> 00:15:32,410
board that shows it if absorption okay

290
00:15:30,250 --> 00:15:35,649
so the other layers the Browns were are

291
00:15:32,409 --> 00:15:36,879
cooler they absorb and meet the water

292
00:15:35,649 --> 00:15:39,579
bands here in the infrared

293
00:15:36,879 --> 00:15:43,240
whereas Hubble spectrum actually shows

294
00:15:39,580 --> 00:15:46,180
emission at those same man passes in the

295
00:15:43,240 --> 00:15:49,600
infrared this is what they tell me the

296
00:15:46,179 --> 00:15:52,839
strong is evidence so far that they have

297
00:15:49,600 --> 00:15:55,450
seen a stratosphere on a planet around

298
00:15:52,840 --> 00:15:57,129
another star and this is the kind of

299
00:15:55,450 --> 00:15:58,810
cool thing we can look forward to over

300
00:15:57,129 --> 00:16:01,179
the next couple of decades we can

301
00:15:58,809 --> 00:16:03,159
enchant whether or not the things that

302
00:16:01,179 --> 00:16:05,199
happen in our solar system also

303
00:16:03,159 --> 00:16:07,379
happening other solar systems

304
00:16:05,200 --> 00:16:09,899
it's our solar system some house

305
00:16:07,379 --> 00:16:11,759
not because we based a lot of our

306
00:16:09,899 --> 00:16:14,609
science as scientific projections about

307
00:16:11,759 --> 00:16:16,288
the universe on our solar system but

308
00:16:14,609 --> 00:16:16,979
this is a kind of thing that shows us

309
00:16:16,288 --> 00:16:18,958
that okay

310
00:16:16,979 --> 00:16:24,538
yeah it's trap skiers also exist on

311
00:16:18,958 --> 00:16:27,958
extrasolar planets so of course a

312
00:16:24,538 --> 00:16:30,058
squiggly line is for the spectrum is not

313
00:16:27,958 --> 00:16:32,068
suitable for press release so of course

314

00:16:30,058 --> 00:16:37,408
they had to come up with a cool artist

315
00:16:32,068 --> 00:16:40,738
illustration so this is the star 121 and

316
00:16:37,408 --> 00:16:44,519
this is the planet lost 21b because it's

317
00:16:40,739 --> 00:16:47,220
so hot it's actually atmosphere is that

318
00:16:44,519 --> 00:16:50,489
around 4000 degrees they say they

319
00:16:47,220 --> 00:16:53,759
believe that the the some of the

320
00:16:50,489 --> 00:16:55,470
molecules are actually that being

321
00:16:53,759 --> 00:16:58,379
evaporated from the planet and blowing

322
00:16:55,470 --> 00:17:00,119
might be blown off in a wind but it's

323
00:16:58,379 --> 00:17:02,428
very hot in its near side that's tightly

324
00:17:00,119 --> 00:17:05,220
locked and it's actually slightly

325
00:17:02,428 --> 00:17:07,619
egg-shaped because it is filling up

326
00:17:05,220 --> 00:17:09,808
about what they said about 60% of its

327
00:17:07,619 --> 00:17:13,048
rotor flow all right the rough lobe is

328
00:17:09,808 --> 00:17:15,359

the radius at which it actually becomes

329

00:17:13,048 --> 00:17:20,609

totally descend distended and material

330

00:17:15,359 --> 00:17:22,138

and flow away freely so this is this is

331

00:17:20,609 --> 00:17:24,958

a pretty hardest conception that they

332

00:17:22,138 --> 00:17:29,609

have our artists made to show it off all

333

00:17:24,959 --> 00:17:36,840

right I am Rhonda Warren brown dwarf

334

00:17:29,609 --> 00:17:40,048

thank you I did use jargon and a star

335

00:17:36,839 --> 00:17:42,418

okay a star is powered by a

336

00:17:40,048 --> 00:17:46,079

main-sequence stars powered by hydrogen

337

00:17:42,419 --> 00:17:48,509

fusion in its core a brown dwarf reaches

338

00:17:46,079 --> 00:17:50,308

deuterium fusion but never gets big it's

339

00:17:48,509 --> 00:17:53,190

not big enough to reach hydrogen fusion

340

00:17:50,308 --> 00:17:54,690

okay a planet that Jupiter never reaches

341

00:17:53,190 --> 00:17:57,120

deuterium fusion doesn't reach any

342

00:17:54,690 --> 00:17:58,649

fusion whatsoever so the ones that make

343
00:17:57,119 --> 00:18:02,148
this tiny bit of fusion and then fade

344
00:17:58,648 --> 00:18:08,278
away those are brown dwarfs so there but

345
00:18:02,148 --> 00:18:15,679
72 per masses and above okay thank you

346
00:18:08,278 --> 00:18:20,180
for catching me on that featured speaker

347
00:18:15,680 --> 00:18:22,549
tonight is a senior scientist here and I

348
00:18:20,180 --> 00:18:26,600
guess that he'd been here about 30 years

349
00:18:22,549 --> 00:18:28,430
he said no he'd been here 34 years and

350
00:18:26,599 --> 00:18:30,549
then he said you know what I was

351
00:18:28,430 --> 00:18:34,100
actually here five years before that

352
00:18:30,549 --> 00:18:37,309
helping write the proposal that created

353
00:18:34,099 --> 00:18:40,219
this Institute okay this is a guy who's

354
00:18:37,309 --> 00:18:42,769
got so much history he was here and the

355
00:18:40,220 --> 00:18:45,350
genesis of the ideas that created this

356
00:18:42,769 --> 00:18:47,869
building okay and I gotta say you know

357
00:18:45,349 --> 00:18:50,029
this institute is was a totally new

358
00:18:47,869 --> 00:18:52,339
thing in astronomy at the time because

359
00:18:50,029 --> 00:18:55,009
most of the observatories were supported

360
00:18:52,339 --> 00:18:57,679
by staff in an astronomy department at

361
00:18:55,009 --> 00:19:00,200
some university this was an association

362
00:18:57,680 --> 00:19:02,960
of universities running a specific

363
00:19:00,200 --> 00:19:05,720
Institute to just do professional

364
00:19:02,960 --> 00:19:08,870
support of the telescope and it's turned

365
00:19:05,720 --> 00:19:11,240
out fantastically their vision has been

366
00:19:08,869 --> 00:19:13,039
executed incredibly well over the last

367
00:19:11,240 --> 00:19:16,730
thirty years

368
00:19:13,039 --> 00:19:20,990
and let's see his official status is as

369
00:19:16,730 --> 00:19:22,880
senior astronomer and it's a major

370
00:19:20,990 --> 00:19:27,049
primary support for the Space Telescope

371

00:19:22,880 --> 00:19:29,270
imaging spectrograph all right so user

372
00:19:27,049 --> 00:19:31,460
support for that okay so ladies and

373
00:19:29,269 --> 00:19:32,799
gentlemen let's have a warm welcome for

374
00:19:31,460 --> 00:19:44,828
dr. Noland Walburn

375
00:19:32,799 --> 00:19:44,828
[Applause]

376
00:19:55,839 --> 00:20:02,659
thank you well Frank's various

377
00:20:00,019 --> 00:20:05,599
introductions here actually caused me to

378
00:20:02,660 --> 00:20:08,090
add a few preliminary additional

379
00:20:05,599 --> 00:20:11,089
introductory remarks that I wasn't going

380
00:20:08,089 --> 00:20:12,849
to first about or association of

381
00:20:11,089 --> 00:20:15,109
universities for recently astronomy

382
00:20:12,849 --> 00:20:16,459
actually it isn't true that this

383
00:20:15,109 --> 00:20:19,129
Institute was the first place that

384
00:20:16,460 --> 00:20:21,829
operated this way or found that Kitt

385
00:20:19,130 --> 00:20:25,580

Peak in Arizona and Sarah Tallulah in

386

00:20:21,829 --> 00:20:27,379

Chile the 1950s in the 1960s and these

387

00:20:25,579 --> 00:20:29,389

are the first visitor centers where

388

00:20:27,380 --> 00:20:31,490

anyone could come and observe based on

389

00:20:29,390 --> 00:20:33,620

competitive peer reviewed proposals

390

00:20:31,490 --> 00:20:36,250

instead of just people who owned the

391

00:20:33,619 --> 00:20:38,599

telescopes so or already had that

392

00:20:36,250 --> 00:20:42,230

paradigm in mind when we proposed to

393

00:20:38,599 --> 00:20:45,789

NASA to manage this incident and were

394

00:20:42,230 --> 00:21:03,589

successful against many predictions

395

00:20:45,789 --> 00:21:07,549

Princeton had which also relates to the

396

00:21:03,589 --> 00:21:09,169

live data that was distributed and also

397

00:21:07,549 --> 00:21:11,740

relates to my talk so I thought I'd say

398

00:21:09,170 --> 00:21:14,240

a couple of words about that this is

399

00:21:11,740 --> 00:21:17,779

probably most of you know is the first

400
00:21:14,240 --> 00:21:20,809
supernova this close to the Sun since

401
00:21:17,779 --> 00:21:23,329
the invention of the telescope so that

402
00:21:20,809 --> 00:21:26,599
was 1610 by the way so we're pretty

403
00:21:23,329 --> 00:21:29,029
excited about that and I'm going to be

404
00:21:26,599 --> 00:21:32,299
showing you some very peculiar

405
00:21:29,029 --> 00:21:33,889
interesting massive stars which are near

406
00:21:32,299 --> 00:21:36,019
the ends of their lifetimes and behaving

407
00:21:33,890 --> 00:21:37,910
very strangely and we don't understand

408
00:21:36,019 --> 00:21:40,910
the details of why they were doing this

409
00:21:37,910 --> 00:21:43,070
that's what we're working on but as you

410
00:21:40,910 --> 00:21:45,800
know probably all massive stars and

411
00:21:43,069 --> 00:21:47,659
their lives is super novae final

412
00:21:45,799 --> 00:21:50,690
collapse and explosion or maybe

413
00:21:47,660 --> 00:21:53,000
implosion in some very massive cases and

414
00:21:50,690 --> 00:21:55,430
yeah we would expect them to do some

415
00:21:53,000 --> 00:21:59,509
strange things before that happens about

416
00:21:55,430 --> 00:22:01,310
this one this star is only 20 solar

417
00:21:59,509 --> 00:22:04,759
masses although that's twice as massive

418
00:22:01,309 --> 00:22:06,799
as those masses that make super annoying

419
00:22:04,759 --> 00:22:09,710
and the star was known is just a normal

420
00:22:06,799 --> 00:22:11,480
ordinary blue supergiant and the LMC no

421
00:22:09,710 --> 00:22:15,500
one paid much attention to it until one

422
00:22:11,480 --> 00:22:18,049
fine day February 23rd 1987 it blew up

423
00:22:15,500 --> 00:22:19,670
and then it was too late to go back and

424
00:22:18,049 --> 00:22:21,829
study the details of the star that blew

425
00:22:19,670 --> 00:22:24,440
up we very much wish we had done that

426
00:22:21,829 --> 00:22:26,539
and but it did nothing exceptional to

427
00:22:24,440 --> 00:22:29,799
draw attention to itself until it

428

00:22:26,539 --> 00:22:32,869
exploded and that was a big surprise

429
00:22:29,799 --> 00:22:34,609
these stars will explode sometime soon

430
00:22:32,869 --> 00:22:40,729
and they are drawing attention to

431
00:22:34,609 --> 00:22:43,159
themselves so I mean this lead image

432
00:22:40,730 --> 00:22:47,410
here is the whole large magellanic cloud

433
00:22:43,160 --> 00:22:50,360
which you may know is a relatively small

434
00:22:47,410 --> 00:22:53,230
moderate sized satellite galaxy of our

435
00:22:50,359 --> 00:22:55,759
own it's very important to the study of

436
00:22:53,230 --> 00:22:57,500
many things because it is far enough

437
00:22:55,759 --> 00:22:58,970
away that we can see it as an

438
00:22:57,500 --> 00:23:02,660
independent galaxy it has its own

439
00:22:58,970 --> 00:23:05,059
evolution and heavy element content I'm

440
00:23:02,660 --> 00:23:06,470
different from our galaxy but yet it's

441
00:23:05,059 --> 00:23:07,759
near enough that with large ground-based

442
00:23:06,470 --> 00:23:10,250

telescopes in the Hubble Space Telescope

443

00:23:07,759 --> 00:23:12,589

we can study individual stars in it and

444

00:23:10,250 --> 00:23:14,420

so that's a very useful bootstrap

445

00:23:12,589 --> 00:23:16,279

between what we can do in our galaxy and

446

00:23:14,420 --> 00:23:18,769

then more distant galaxies where we

447

00:23:16,279 --> 00:23:21,799

don't have this level of resolution and

448

00:23:18,769 --> 00:23:23,650

information content so as I've already

449

00:23:21,799 --> 00:23:27,470

mentioned we've been working on these

450

00:23:23,650 --> 00:23:28,880

very peculiar variable stars and I just

451

00:23:27,470 --> 00:23:30,890

published a paper we just published a

452

00:23:28,880 --> 00:23:32,870

paper my collaborators there all of whom

453

00:23:30,890 --> 00:23:35,600

happened to be from Argentina

454

00:23:32,869 --> 00:23:38,179

I wasn't born there but I spent eight

455

00:23:35,599 --> 00:23:40,189

years there when I was a child and the

456

00:23:38,180 --> 00:23:43,400

other three are Argentines although two

457
00:23:40,190 --> 00:23:46,029
of them now work in Chile las Cabañas

458
00:23:43,400 --> 00:23:48,500
and La Serena close to the big

459
00:23:46,029 --> 00:23:50,210
observatories like Silla allowing

460
00:23:48,500 --> 00:23:51,680
other ones because the climate in Chile

461
00:23:50,210 --> 00:23:55,569
is better than in Argentina for

462
00:23:51,680 --> 00:24:00,049
astronomy and so it's a hotbed of major

463
00:23:55,569 --> 00:24:03,980
international observatories they're

464
00:24:00,049 --> 00:24:05,659
still under construction so this shows

465
00:24:03,980 --> 00:24:07,009
you the location of the three objects

466
00:24:05,660 --> 00:24:09,290
and when we talking about tonight

467
00:24:07,009 --> 00:24:10,759
the paper actually involves five but

468
00:24:09,289 --> 00:24:14,529
these are the three that we have the

469
00:24:10,759 --> 00:24:22,160
most information about in our study and

470
00:24:14,529 --> 00:24:24,319
so hmm I'll start by showing a graph and

471
00:24:22,160 --> 00:24:27,170
a few images but this talk I'm going to

472
00:24:24,319 --> 00:24:29,450
show them show you mostly like curves

473
00:24:27,170 --> 00:24:31,190
that is how the brightness of these

474
00:24:29,450 --> 00:24:32,240
stars changes as a function of time in

475
00:24:31,190 --> 00:24:34,640
spectrum

476
00:24:32,240 --> 00:24:35,930
oh no not spectrum but I hope to

477
00:24:34,640 --> 00:24:38,360
convince at least some of you by the end

478
00:24:35,930 --> 00:24:40,190
of this talk that spectra are at least

479
00:24:38,359 --> 00:24:44,179
as beautiful if not more beautiful than

480
00:24:40,190 --> 00:24:47,000
images because they tell you so much

481
00:24:44,180 --> 00:24:49,310
more you that that's how we learn the

482
00:24:47,000 --> 00:24:52,069
physics of the stars is from their

483
00:24:49,309 --> 00:24:53,509
spectra huh and so I'm gonna not gonna

484
00:24:52,069 --> 00:24:54,439
assume as some of you maybe have

485

00:24:53,509 --> 00:24:58,309
something with the area with

486
00:24:54,440 --> 00:25:00,500
spectroscopy and but I'm gonna explain

487
00:24:58,309 --> 00:25:03,169
some for those who don't and may be

488
00:25:00,500 --> 00:25:09,079
interested in that because you can learn

489
00:25:03,170 --> 00:25:10,910
a lot if you bear with me and I'll show

490
00:25:09,079 --> 00:25:13,849
you but we're starting off here with a

491
00:25:10,910 --> 00:25:16,430
graph the only graph I think I have it

492
00:25:13,849 --> 00:25:17,569
looks pretty complicated and but don't

493
00:25:16,430 --> 00:25:19,039
worry about it we're not going to talk

494
00:25:17,569 --> 00:25:20,990
about everything that's in here you can

495
00:25:19,039 --> 00:25:26,149
begin by ignoring all the red and blue

496
00:25:20,990 --> 00:25:28,640
points for something else we're

497
00:25:26,150 --> 00:25:32,030
interested in this green triangles and

498
00:25:28,640 --> 00:25:33,560
lines there but first I'm explaining

499
00:25:32,029 --> 00:25:35,480

what the diagram is this is a

500

00:25:33,559 --> 00:25:36,649
hertzsprung-russell diagram in

501

00:25:35,480 --> 00:25:39,079
particular a theoretical

502

00:25:36,650 --> 00:25:40,759
hertzsprung-russell diagram and after

503

00:25:39,079 --> 00:25:42,169
two of the most outstanding astronomers

504

00:25:40,759 --> 00:25:44,900
of the 20th century who discovered it

505

00:25:42,170 --> 00:25:48,050
and they worked with observations first

506

00:25:44,900 --> 00:25:50,660
and they may be brightnesses of the

507

00:25:48,049 --> 00:25:52,730
stars and their spectral types this has

508

00:25:50,660 --> 00:25:57,310
now been converted to temperatures these

509

00:25:52,730 --> 00:25:57,309
are tens of thousands of degrees Kelvin

510

00:26:00,519 --> 00:26:07,220
from 50,000 degrees

511

00:26:03,920 --> 00:26:09,350
there's hottest stars to 10,000 degrees

512

00:26:07,220 --> 00:26:11,870
so these these are all hot stars the Sun

513

00:26:09,349 --> 00:26:14,539
is 6,000 degrees so it's kind of even

514
00:26:11,869 --> 00:26:15,339
off this graph so these are massive hot

515
00:26:14,539 --> 00:26:19,210
stars

516
00:26:15,339 --> 00:26:20,769
massive stars get hotter and surprising

517
00:26:19,210 --> 00:26:22,840
enough they have shorter life times then

518
00:26:20,769 --> 00:26:24,039
low mass stars like the Sun because

519
00:26:22,839 --> 00:26:26,079
despite the fact that they have more

520
00:26:24,039 --> 00:26:27,190
mass the nuclear reactions are very

521
00:26:26,079 --> 00:26:28,419
sensitive to temperature they have

522
00:26:27,190 --> 00:26:29,590
higher temperatures and they burn up

523
00:26:28,420 --> 00:26:32,920
faster even though they have more

524
00:26:29,589 --> 00:26:35,980
material to burn so this bold line here

525
00:26:32,920 --> 00:26:37,210
at the left is the main sequence which

526
00:26:35,980 --> 00:26:40,150
is a very important discovery that

527
00:26:37,210 --> 00:26:42,490
hertzsprung-russell did and you put up

528
00:26:40,150 --> 00:26:45,040
all the stars in the sky that you can

529
00:26:42,490 --> 00:26:52,269
with their parameters the 90% of them

530
00:26:45,039 --> 00:26:53,500
along that line why is that well we now

531
00:26:52,269 --> 00:26:55,240
understand why that is when people

532
00:26:53,500 --> 00:27:00,519
discovered this they didn't but we made

533
00:26:55,240 --> 00:27:02,740
a lot of progress in the last decades so

534
00:27:00,519 --> 00:27:06,940
that is the locus of stars in this

535
00:27:02,740 --> 00:27:09,190
diagram of luminosity increasing upwards

536
00:27:06,940 --> 00:27:11,500
and temperature increasing leftwards

537
00:27:09,190 --> 00:27:13,539
while they are burning hydrogen into

538
00:27:11,500 --> 00:27:16,690
helium and that is 90 percent of the

539
00:27:13,539 --> 00:27:18,099
lifetime of any star and so they lie on

540
00:27:16,690 --> 00:27:19,809
this locus and that's called the

541
00:27:18,099 --> 00:27:21,699
main-sequence and here it's labeled with

542

00:27:19,809 --> 00:27:23,859
masses you see from 15 times the mass of

543
00:27:21,700 --> 00:27:25,360
the Sun up to 60 times the mass of the

544
00:27:23,859 --> 00:27:28,149
Sun and so the Stars we're talking about

545
00:27:25,359 --> 00:27:31,449
it more massive than that then then you

546
00:27:28,150 --> 00:27:34,750
see these lines drawn on here these are

547
00:27:31,450 --> 00:27:37,240
evolutionary tracks and so that's what

548
00:27:34,750 --> 00:27:39,250
the stars do in this diagram when they

549
00:27:37,240 --> 00:27:41,410
start to run out of hydrogen fuel and

550
00:27:39,250 --> 00:27:43,960
they begin to evolve as we say they

551
00:27:41,410 --> 00:27:46,180
follow these tracks in the HR diagram

552
00:27:43,960 --> 00:27:52,900
and we now understand a lot that why

553
00:27:46,180 --> 00:27:55,630
that is why they do that and they they

554
00:27:52,900 --> 00:27:58,990
take a certain length of time to evolve

555
00:27:55,630 --> 00:28:01,600
as we say and these dashed lines here

556
00:27:58,990 --> 00:28:03,190

are called isochrones and you see

557

00:28:01,599 --> 00:28:06,159
they're labeled in millions of years and

558

00:28:03,190 --> 00:28:08,200
so that tells you how far the star has

559

00:28:06,160 --> 00:28:10,750
moved away from the main sequence in

560

00:28:08,200 --> 00:28:13,269
that length of time and as I said the

561

00:28:10,750 --> 00:28:15,700
more massive stars go faster and you see

562

00:28:13,269 --> 00:28:17,529
that in two or three million years these

563

00:28:15,700 --> 00:28:20,019
star is it up here at the top are all

564

00:28:17,529 --> 00:28:22,269
the way over here but here in lower

565

00:28:20,019 --> 00:28:23,658
masses 8 or 10 million years they're

566

00:28:22,269 --> 00:28:27,239
just

567

00:28:23,659 --> 00:28:29,220
mmm still probably still burning some

568

00:28:27,239 --> 00:28:30,929
hydrogen dealing because this glitch

569

00:28:29,220 --> 00:28:35,519
here in the tracks is where they really

570

00:28:30,929 --> 00:28:38,399
run out of hydrogen well so we're

571
00:28:35,519 --> 00:28:41,249
interested in these green triangles

572
00:28:38,398 --> 00:28:42,898
which some are which are single but some

573
00:28:41,249 --> 00:28:46,139
of which they're two of joined by a

574
00:28:42,898 --> 00:28:48,868
dashed green line and that is how these

575
00:28:46,138 --> 00:28:51,378
luminous blue variables behave in in the

576
00:28:48,868 --> 00:28:54,808
HR diagram as they're undergoing

577
00:28:51,378 --> 00:28:57,839
outbursts and so these stars are so

578
00:28:54,808 --> 00:28:59,940
luminous that they can't hold themselves

579
00:28:57,839 --> 00:29:02,759
together a star is a battle between

580
00:28:59,940 --> 00:29:04,558
gravity trying to collapse it its fate

581
00:29:02,759 --> 00:29:06,710
is sealed as soon as the star forms a

582
00:29:04,558 --> 00:29:09,239
star forms from a cloud of gas in

583
00:29:06,710 --> 00:29:11,489
interstellar space that begins to

584
00:29:09,239 --> 00:29:12,929
contract and heat up and it gets hotter

585
00:29:11,489 --> 00:29:14,788
and hotter until it reaches millions of

586
00:29:12,929 --> 00:29:16,499
degrees in interiors in its interior and

587
00:29:14,788 --> 00:29:19,679
that's where nuclear reactions begin

588
00:29:16,499 --> 00:29:22,108
and so that produces a pressure outwards

589
00:29:19,679 --> 00:29:23,879
and so a star is just a huge mass of gas

590
00:29:22,108 --> 00:29:25,288
in equilibrium between gravity inwards

591
00:29:23,878 --> 00:29:29,099
and the pressure from nuclear reactions

592
00:29:25,288 --> 00:29:30,628
outwards and you can maintain that you

593
00:29:29,099 --> 00:29:31,829
have a stable star but as I already

594
00:29:30,628 --> 00:29:34,678
mentioned they don't run out of fuel

595
00:29:31,829 --> 00:29:36,509
it's burning fuel and most of its life

596
00:29:34,679 --> 00:29:39,419
time is spent the burning hydrogen the

597
00:29:36,509 --> 00:29:41,700
simplest to helium then the next atom in

598
00:29:39,419 --> 00:29:43,470
the periodic table but then it can go

599

00:29:41,700 --> 00:29:45,720
through subsequent stages where it gets

600
00:29:43,470 --> 00:29:47,159
even hotter and burns heavier elements

601
00:29:45,720 --> 00:29:48,960
and two even heavier ones and in fact

602
00:29:47,159 --> 00:29:50,940
that's very important because there are

603
00:29:48,960 --> 00:29:52,649
those nuclear reactions not only a lot

604
00:29:50,940 --> 00:29:54,720
of stars do exist but they synthesize

605
00:29:52,648 --> 00:29:57,329
all the chemical elements in the

606
00:29:54,720 --> 00:29:59,009
universe heavier than hydrogen and

607
00:29:57,329 --> 00:30:00,509
helium which come from the Big Bang a

608
00:29:59,009 --> 00:30:02,038
little bit of lithium maybe but

609
00:30:00,509 --> 00:30:03,899
everything were made out of was made

610
00:30:02,038 --> 00:30:07,798
inside of stars so the atoms and your

611
00:30:03,898 --> 00:30:10,398
way were made inside of a star or in the

612
00:30:07,798 --> 00:30:12,450
explosions the heavier elements are

613
00:30:10,398 --> 00:30:14,518

really heavy elements heavier than iron

614

00:30:12,450 --> 00:30:16,558

many of them are made in the actual

615

00:30:14,519 --> 00:30:18,329

supernova explosions when these stars

616

00:30:16,558 --> 00:30:20,519

die and then that's blown out in their

617

00:30:18,329 --> 00:30:22,288

space and new generations of stars can

618

00:30:20,519 --> 00:30:24,569

form out of that and riched material and

619

00:30:22,288 --> 00:30:27,058

the Sun is at least a second or maybe a

620

00:30:24,569 --> 00:30:31,408

third generation star because we could

621

00:30:27,058 --> 00:30:33,538

not exist with the chemical composition

622

00:30:31,409 --> 00:30:35,430

of the first stars I dream helium you

623

00:30:33,538 --> 00:30:37,680

can't make molecules

624

00:30:35,430 --> 00:30:39,330

people out of that so you need these

625

00:30:37,680 --> 00:30:41,330

heavier elements made in successive

626

00:30:39,329 --> 00:30:45,109

generation of stars in order to have

627

00:30:41,329 --> 00:30:47,339

life and everything else we have here

628
00:30:45,109 --> 00:30:52,469
well getting back to our main story here

629
00:30:47,339 --> 00:30:54,149
now these massive stars they they get

630
00:30:52,470 --> 00:31:01,740
into trouble when they try to move over

631
00:30:54,150 --> 00:31:05,190
here and they get more luminous their

632
00:31:01,740 --> 00:31:06,750
winds stars even normal massive stars

633
00:31:05,190 --> 00:31:10,950
lose material all the time through

634
00:31:06,750 --> 00:31:13,259
stellar winds but it's a steady quiet

635
00:31:10,950 --> 00:31:14,580
flow and that's okay but here then they

636
00:31:13,259 --> 00:31:15,569
start to get unstable and they can't

637
00:31:14,579 --> 00:31:18,269
hold themselves together

638
00:31:15,569 --> 00:31:20,579
so these stars have developed kind of a

639
00:31:18,269 --> 00:31:22,109
last-ditch mechanism to extend their

640
00:31:20,579 --> 00:31:24,000
lifetimes if you will which we still

641
00:31:22,109 --> 00:31:27,359
don't understand in detail in which I

642
00:31:24,000 --> 00:31:32,730
have these episodes of enhanced mass

643
00:31:27,359 --> 00:31:37,519
loss and they inflate and they become

644
00:31:32,730 --> 00:31:40,500
cooler you see them becoming cooler and

645
00:31:37,519 --> 00:31:42,450
but this is not the evolution of a

646
00:31:40,500 --> 00:31:45,000
nuclear evolution of these tracks this

647
00:31:42,450 --> 00:31:47,360
is a an event which takes place on

648
00:31:45,000 --> 00:31:50,819
timescales of thousands of years or

649
00:31:47,359 --> 00:31:54,809
hundreds of thousands of years and can

650
00:31:50,819 --> 00:31:57,210
repeat so the star gets here undergoes

651
00:31:54,809 --> 00:31:59,519
this instability moves over here and it

652
00:31:57,210 --> 00:32:02,700
moves back and it can do that several

653
00:31:59,519 --> 00:32:05,700
times with enhanced ejection of material

654
00:32:02,700 --> 00:32:07,799
and that's what a luminous blue variable

655
00:32:05,700 --> 00:32:10,230
is it's an unstable massive star near

656

00:32:07,799 --> 00:32:11,700
the end of its lifetime this dark line

657
00:32:10,230 --> 00:32:15,000
here is called the Humphreys Davidson

658
00:32:11,700 --> 00:32:16,680
limit after two astronomers who

659
00:32:15,000 --> 00:32:19,349
discovered it and found that there are

660
00:32:16,680 --> 00:32:21,480
no stars over here you go over and there

661
00:32:19,349 --> 00:32:22,679
are red stars over here but there's a

662
00:32:21,480 --> 00:32:25,200
limit that goes kind of like this and

663
00:32:22,680 --> 00:32:27,150
that and you look at the most luminous

664
00:32:25,200 --> 00:32:29,789
stars and external galaxies and no stars

665
00:32:27,150 --> 00:32:31,500
there they don't make it there they hit

666
00:32:29,789 --> 00:32:35,849
this instability limit and they do this

667
00:32:31,500 --> 00:32:37,079
and then we thought then they they lost

668
00:32:35,849 --> 00:32:38,579
a lot of material that became another

669
00:32:37,079 --> 00:32:41,759
kind of super star called the wolf or a

670
00:32:38,579 --> 00:32:43,079

star before exploding but now just

671

00:32:41,759 --> 00:32:44,190

within the last few years we have

672

00:32:43,079 --> 00:32:45,339

evidence that some of these stars

673

00:32:44,190 --> 00:32:47,620

explode directly

674

00:32:45,339 --> 00:32:49,839

as long as burials so that's our hope

675

00:32:47,619 --> 00:32:52,659

that we'll see one doing you know are a

676

00:32:49,839 --> 00:32:54,789

real block block right now and

677

00:32:52,660 --> 00:32:56,560

understanding the end stages of massive

678

00:32:54,789 --> 00:33:00,670

stars is seeing a star that we know and

679

00:32:56,559 --> 00:33:01,899

studied and will do it first thing we

680

00:33:00,670 --> 00:33:03,640

see is the supernova explosions I'm

681

00:33:01,900 --> 00:33:05,500

listen calyx and it's too late you can't

682

00:33:03,640 --> 00:33:06,820

go back and see what kind of star did

683

00:33:05,500 --> 00:33:08,319

that you can try to get some information

684

00:33:06,819 --> 00:33:11,319

some inferences maybe you have some old

685
00:33:08,319 --> 00:33:12,490
images is worth it was there but we

686
00:33:11,319 --> 00:33:14,409
would like to see one of these stars

687
00:33:12,490 --> 00:33:16,299
that we have observed doing all sorts of

688
00:33:14,410 --> 00:33:18,820
things explode and then we would know

689
00:33:16,299 --> 00:33:20,200
things that we don't know so actually

690
00:33:18,819 --> 00:33:23,169
two of the three stars I'm going to show

691
00:33:20,200 --> 00:33:24,910
you are in this diagram are 127 it's a

692
00:33:23,170 --> 00:33:26,860
red cliff for South Africa where they

693
00:33:24,910 --> 00:33:28,090
describe some of the stars they're there

694
00:33:26,859 --> 00:33:29,769
in the Magellanic Cloud the Large

695
00:33:28,089 --> 00:33:31,659
Magellanic Cloud are 127 it's been

696
00:33:29,769 --> 00:33:33,759
observed to have this huge excursion

697
00:33:31,660 --> 00:33:35,830
here from you know 30 thousand degrees

698
00:33:33,759 --> 00:33:39,069
down to ten thousand degrees and back

699
00:33:35,829 --> 00:33:40,839
again and r71 and you don't want to

700
00:33:39,069 --> 00:33:42,039
believe the plot that's this little line

701
00:33:40,839 --> 00:33:45,669
here you don't believe that too much

702
00:33:42,039 --> 00:33:47,980
because it looks like it had lower and

703
00:33:45,670 --> 00:33:49,480
when I say lower mass but it's now an

704
00:33:47,980 --> 00:33:51,279
outburst it's the brightest star in the

705
00:33:49,480 --> 00:33:54,069
large emergent that cloud right now and

706
00:33:51,279 --> 00:33:56,829
I'll show you that and it's moved up as

707
00:33:54,069 --> 00:33:59,200
opposed to horizontally as these stars

708
00:33:56,829 --> 00:34:03,189
do and so you know there's always new

709
00:33:59,200 --> 00:34:09,220
stuff to discover and then try to

710
00:34:03,190 --> 00:34:10,929
understand in astronomy so now some of

711
00:34:09,219 --> 00:34:12,579
this is kind of technical and difficult

712
00:34:10,929 --> 00:34:13,779
and I'm really trying to do my best to

713

00:34:12,579 --> 00:34:16,210
explain without jargon but if I don't

714
00:34:13,780 --> 00:34:18,760
succeed I welcome a question or a

715
00:34:16,210 --> 00:34:20,320
clarification as I'm talking any more

716
00:34:18,760 --> 00:34:21,550
extended discussion let's save that for

717
00:34:20,320 --> 00:34:23,559
the end because otherwise I won't get

718
00:34:21,550 --> 00:34:25,539
through it but if I use a term or

719
00:34:23,559 --> 00:34:26,889
something or said something that isn't

720
00:34:25,539 --> 00:34:29,139
clear and you think can be clarified

721
00:34:26,889 --> 00:34:31,379
with a few words please do like here's

722
00:34:29,139 --> 00:34:31,379
what

723
00:34:42,559 --> 00:34:48,019
very we have obviously observed money

724
00:34:45,239 --> 00:34:52,079
for thousands of years yet but they have

725
00:34:48,019 --> 00:34:53,460
both outbursts and eruptions and I'm

726
00:34:52,079 --> 00:34:55,739
gonna be talking about outbursts mainly

727
00:34:53,460 --> 00:34:57,840

which are these things that last decades

728

00:34:55,739 --> 00:35:01,469

maybe and we have observed the full

729

00:34:57,840 --> 00:35:02,970

cycle for one we had and I'm going to

730

00:35:01,469 --> 00:35:04,739

show you for the first time most people

731

00:35:02,969 --> 00:35:06,029

didn't see it the last month paper again

732

00:35:04,739 --> 00:35:08,449

right the second one which is observed

733

00:35:06,030 --> 00:35:11,730

over the full range of outbursts but

734

00:35:08,449 --> 00:35:15,929

then they more infrequently have giant

735

00:35:11,730 --> 00:35:17,519

eruptions in which they eject much more

736

00:35:15,929 --> 00:35:23,309

and denser material and create

737

00:35:17,519 --> 00:35:25,170

circumstellar nebulae and we we've

738

00:35:23,309 --> 00:35:28,259

observed some of those events probably

739

00:35:25,170 --> 00:35:30,300

but more than that we can observe such

740

00:35:28,260 --> 00:35:30,840

events ejected the thousands of years

741

00:35:30,300 --> 00:35:33,030

ago

742

00:35:30,840 --> 00:35:34,710
and for how long ago from their

743

00:35:33,030 --> 00:35:36,180
velocities and sizes how long ago they

744

00:35:34,710 --> 00:35:39,780
were ejected and that's where that

745

00:35:36,179 --> 00:35:48,769
thousands of years comment comes from so

746

00:35:39,780 --> 00:35:51,880
it's a good question why does it go back

747

00:35:48,769 --> 00:35:51,880
[Music]

748

00:35:51,929 --> 00:35:59,429
oh the this little glitch here yes

749

00:35:56,329 --> 00:36:03,059
that's that's the terminal age main

750

00:35:59,429 --> 00:36:04,980
sequence and that's where really the

751

00:36:03,059 --> 00:36:08,069
helium the hydrogen burning stops

752

00:36:04,980 --> 00:36:10,079
completely and so you know this again

753

00:36:08,068 --> 00:36:12,179
this is a plot of brightness versus

754

00:36:10,079 --> 00:36:15,089
temperature so when stars get to that

755

00:36:12,179 --> 00:36:17,250
point they they do a little retrograde

756
00:36:15,088 --> 00:36:20,699
is that's a good word for it a little

757
00:36:17,250 --> 00:36:22,440
glitch in this diagram and that's as

758
00:36:20,699 --> 00:36:25,769
their interiors readjust and then they

759
00:36:22,440 --> 00:36:27,750
cross especially these Lord masses they

760
00:36:25,769 --> 00:36:29,909
cross this pretty rapidly and then they

761
00:36:27,750 --> 00:36:31,500
go over here become red giants and red

762
00:36:29,909 --> 00:36:35,098
supergiant's where they've been burn

763
00:36:31,500 --> 00:36:36,838
helium into carbon and that that can

764
00:36:35,099 --> 00:36:41,068
last the 10% of the hydrogen brain

765
00:36:36,838 --> 00:36:44,429
lifetime million years started last ten

766
00:36:41,068 --> 00:36:47,429
million years and so this is part of the

767
00:36:44,429 --> 00:36:50,009
readjustment of the Stars interior as it

768
00:36:47,429 --> 00:36:52,259
goes from losing its hydrogen source to

769
00:36:50,010 --> 00:36:53,760
gaining its helium source but and then

770

00:36:52,260 --> 00:36:56,400
it can go on and burn carbon and then

771
00:36:53,760 --> 00:36:58,410
burn the various elements up to silicon

772
00:36:56,400 --> 00:37:01,880
the most massive stars that last three

773
00:36:58,409 --> 00:37:04,078
days so they run out of tricks and then

774
00:37:01,880 --> 00:37:06,180
there's the final collapse because the

775
00:37:04,079 --> 00:37:13,950
energy goes away but the gravity is

776
00:37:06,179 --> 00:37:15,769
always there okay well let's move on I'm

777
00:37:13,949 --> 00:37:20,368
not gonna spend this much time on all

778
00:37:15,769 --> 00:37:22,380
grams I hope so first object were going

779
00:37:20,369 --> 00:37:24,420
to blur is are 127 which you heard about

780
00:37:22,380 --> 00:37:26,130
then saw it's located near 30 artists

781
00:37:24,420 --> 00:37:28,889
those of you who've been here a lot

782
00:37:26,130 --> 00:37:30,240
before hundreds on my previous talks are

783
00:37:28,889 --> 00:37:31,949
familiar with 32 right us this is a

784
00:37:30,239 --> 00:37:34,259

third Ross region action that those

785

00:37:31,949 --> 00:37:36,598

nebula is half off the screen here it's

786

00:37:34,260 --> 00:37:38,309

appear because that's not what we're

787

00:37:36,599 --> 00:37:40,318

talking about today this is the site of

788

00:37:38,309 --> 00:37:42,720

formation of the most massive star is

789

00:37:40,318 --> 00:37:44,099

known at the prison time up to 300 solar

790

00:37:42,719 --> 00:37:46,139

masses we didn't know until very

791

00:37:44,099 --> 00:37:47,910

recently that can be stars that massive

792

00:37:46,139 --> 00:37:49,828

but you see all these different kinds of

793

00:37:47,909 --> 00:37:52,679

structures here's some with nebulosity

794

00:37:49,829 --> 00:37:54,329

some without these are all massive stars

795

00:37:52,679 --> 00:37:56,460

of different masses and angles if all

796

00:37:54,329 --> 00:37:58,289

thing doing their thing in this large

797

00:37:56,460 --> 00:37:59,070

region and and if we understood why

798

00:37:58,289 --> 00:38:01,410

every star

799
00:37:59,070 --> 00:38:02,640
where is and these nebulosity so much

800
00:38:01,409 --> 00:38:04,889
you're ejected and some of which are

801
00:38:02,639 --> 00:38:06,210
just fluorescing we would know a lot

802
00:38:04,889 --> 00:38:07,949
more than we do today and someday we

803
00:38:06,210 --> 00:38:10,829
will that's is what we study and in

804
00:38:07,949 --> 00:38:12,539
particular we study our 127 which I can

805
00:38:10,829 --> 00:38:17,369
have in mark but I can point out to you

806
00:38:12,539 --> 00:38:20,880
again this Oh supernova 1987a by the way

807
00:38:17,369 --> 00:38:22,920
is right there oh and I forgot another

808
00:38:20,880 --> 00:38:26,250
thing I was gonna mention you see in

809
00:38:22,920 --> 00:38:28,380
your diagram here the supernova 87a is

810
00:38:26,250 --> 00:38:30,869
is inside that ring the famous ring

811
00:38:28,380 --> 00:38:34,710
there are two stars beside it those are

812
00:38:30,869 --> 00:38:37,289
called stars 2 and 3 and the original

813
00:38:34,710 --> 00:38:39,389
star that exploded is star one and it

814
00:38:37,289 --> 00:38:41,789
was originally three magnitudes brighter

815
00:38:39,389 --> 00:38:43,650
than those other two stars it was twelve

816
00:38:41,789 --> 00:38:45,300
nine to those two or fifteen that's a

817
00:38:43,650 --> 00:38:46,880
factor of sixteen in brightness so you

818
00:38:45,300 --> 00:38:49,140
can believe it's not there anymore right

819
00:38:46,880 --> 00:38:51,900
what we see there in the middle is just

820
00:38:49,139 --> 00:38:54,839
the blast wave from the explosion coming

821
00:38:51,900 --> 00:38:56,280
out but that star is gone so we know

822
00:38:54,840 --> 00:38:58,350
that but there was initially some

823
00:38:56,280 --> 00:38:59,850
confusion about which star had exploded

824
00:38:58,349 --> 00:39:03,989
and how many stars there were there and

825
00:38:59,849 --> 00:39:06,119
I actually discovered star 3 when the

826
00:39:03,989 --> 00:39:08,849
fader one down here just as a bulge on

827

00:39:06,119 --> 00:39:10,769
the overexposed image of the star that

828
00:39:08,849 --> 00:39:13,860
exploded in pre explosion images I had

829
00:39:10,769 --> 00:39:16,820
of theater artists back when I was on

830
00:39:13,860 --> 00:39:16,820
the Saratoga staff

831
00:39:17,170 --> 00:39:22,778
and I got some credit for there was a

832
00:39:20,170 --> 00:39:25,000
telegram came out say oh that because

833
00:39:22,778 --> 00:39:27,190
there are still two stars there yes

834
00:39:25,000 --> 00:39:28,869
there's still two stars there but not

835
00:39:27,190 --> 00:39:31,720
that one Wow

836
00:39:28,869 --> 00:39:37,740
so here this is a fantastic region as it

837
00:39:31,719 --> 00:39:37,739
contains 87 a which is right there and

838
00:39:38,460 --> 00:39:44,170
here is this little group of stars here

839
00:39:41,588 --> 00:39:45,670
I want you to see two bright stars and

840
00:39:44,170 --> 00:39:46,450
then two faded once I put an angle

841
00:39:45,670 --> 00:39:50,200

there okay

842

00:39:46,449 --> 00:39:51,368
and the one here in the the bright star

843

00:39:50,199 --> 00:39:59,710
of the brighter star to the right is our

844

00:39:51,369 --> 00:40:01,510
127 current behavior and but that's

845

00:39:59,710 --> 00:40:03,849
where it lies you see it's an evolved

846

00:40:01,510 --> 00:40:06,400
region okay the youngest regions have

847

00:40:03,849 --> 00:40:08,140
all gas and dust here these stars have

848

00:40:06,400 --> 00:40:10,119
evolved they've blown it all the way it

849

00:40:08,139 --> 00:40:12,278
looks like almost like a ring of stars

850

00:40:10,119 --> 00:40:13,599
here and you just tell by looking at

851

00:40:12,278 --> 00:40:15,730
these are older stars than the one

852

00:40:13,599 --> 00:40:17,890
thirty or on us because they've blown

853

00:40:15,730 --> 00:40:22,869
away all the gas and dust that they had

854

00:40:17,889 --> 00:40:24,879
around them after they formed but this

855

00:40:22,869 --> 00:40:27,130
is a low-resolution large field thing

856
00:40:24,880 --> 00:40:29,588
which a major which is useful to have

857
00:40:27,130 --> 00:40:33,338
but we want to know more we want higher

858
00:40:29,588 --> 00:40:34,778
resolution and more detail and so here

859
00:40:33,338 --> 00:40:37,838
are those same stars I just showed you

860
00:40:34,778 --> 00:40:39,338
and in a higher resolution image now

861
00:40:37,838 --> 00:40:42,880
what looked like the two brighter stars

862
00:40:39,338 --> 00:40:44,409
are actually these two clusters they

863
00:40:42,880 --> 00:40:46,720
weren't single stars and that's a big

864
00:40:44,409 --> 00:40:50,018
problem even that dark spot which is a

865
00:40:46,719 --> 00:40:52,328
nearest neighbor it's really a single

866
00:40:50,018 --> 00:40:53,618
star or just two or more stars so close

867
00:40:52,329 --> 00:40:54,759
together that we can't resolve them and

868
00:40:53,619 --> 00:40:57,539
so we're always looking for higher

869
00:40:54,759 --> 00:41:00,519
resolution to answer that question so

870
00:40:57,539 --> 00:41:02,920
you can see so these are kind of quiet

871
00:41:00,518 --> 00:41:05,139
sand blue stars and these clusters some

872
00:41:02,920 --> 00:41:08,139
brighter ones some fainter ones and but

873
00:41:05,139 --> 00:41:11,230
here is our 127 itself surrounded by

874
00:41:08,139 --> 00:41:14,379
this red halo and I didn't put that

875
00:41:11,230 --> 00:41:18,909
there it's there drawing attention to

876
00:41:14,380 --> 00:41:21,039
itself and actually when it had its

877
00:41:18,909 --> 00:41:22,149
major outburst which I also helped

878
00:41:21,039 --> 00:41:27,099
discover and

879
00:41:22,150 --> 00:41:29,619
in 80 it became much brighter than this

880
00:41:27,099 --> 00:41:31,240
star I went down to start to observe

881
00:41:29,619 --> 00:41:33,670
after I left the staff and I went to the

882
00:41:31,239 --> 00:41:35,649
field and I sat there for a while and

883
00:41:33,670 --> 00:41:37,028
see how I figured out what was going on

884

00:41:35,650 --> 00:41:38,230
it's because the field was completely

885
00:41:37,028 --> 00:41:39,460
different from what had been the last

886
00:41:38,230 --> 00:41:41,409
time I looked at it and it's because

887
00:41:39,460 --> 00:41:42,608
this star which had been the brightest

888
00:41:41,409 --> 00:41:45,219
was no longer the brightest then this

889
00:41:42,608 --> 00:41:48,639
one was way brighter by several

890
00:41:45,219 --> 00:41:50,730
magnitudes what this red glow is this is

891
00:41:48,639 --> 00:41:52,989
a sample of one of these circumstellar

892
00:41:50,730 --> 00:41:55,028
shells that was ejected there a few

893
00:41:52,989 --> 00:41:58,088
thousand years ago maybe and it is

894
00:41:55,028 --> 00:41:59,469
glowing in the light of nebula emission

895
00:41:58,088 --> 00:42:02,588
lines of hydrogen alpha but also

896
00:41:59,469 --> 00:42:05,588
especially nitrogen which is too strong

897
00:42:02,588 --> 00:42:08,980
lines on either side of each alpha and

898
00:42:05,588 --> 00:42:10,778

this these stars these massive stars

899

00:42:08,980 --> 00:42:12,670

they they undergo nuclear reactions I

900

00:42:10,778 --> 00:42:14,289

can't give you all detail of massive

901

00:42:12,670 --> 00:42:17,528

star evolution in the time I have but

902

00:42:14,289 --> 00:42:20,680

massive stars burn helium to hydrogen on

903

00:42:17,528 --> 00:42:22,298

what's hydrogen to helium on what's

904

00:42:20,679 --> 00:42:25,179

called the CNO cycle it's a series of

905

00:42:22,298 --> 00:42:26,829

reactions which very rapidly lock up all

906

00:42:25,179 --> 00:42:29,469

of the carbon nitrogen oxygen in

907

00:42:26,829 --> 00:42:31,420

nitrogen because that's the slowest

908

00:42:29,469 --> 00:42:33,250

reaction it's a bottleneck now this

909

00:42:31,420 --> 00:42:35,710

material gets mixed up to the surface of

910

00:42:33,250 --> 00:42:37,869

the star or rejected before the reaction

911

00:42:35,710 --> 00:42:39,269

go to completion you can see that and so

912

00:42:37,869 --> 00:42:41,920

you can actually see the nuclear

913
00:42:39,269 --> 00:42:44,619
reaction products of a given star on its

914
00:42:41,920 --> 00:42:46,599
own surface isn't that amazing and that

915
00:42:44,619 --> 00:42:50,338
tells you of course I don't amount about

916
00:42:46,599 --> 00:42:55,180
what star is doing how its evolving and

917
00:42:50,338 --> 00:42:58,028
yes far away from the other stars of the

918
00:42:55,179 --> 00:42:59,949
cluster is our 127 maybe just the other

919
00:42:58,028 --> 00:43:05,108
star right next to it I know we can't

920
00:42:59,949 --> 00:43:08,909
really see the depth there yeah a few a

921
00:43:05,108 --> 00:43:11,170
few parts that I happen to know that the

922
00:43:08,909 --> 00:43:12,460
this is actually I said it's high

923
00:43:11,170 --> 00:43:14,798
resolution range and it is higher than

924
00:43:12,460 --> 00:43:16,929
the previous one but it's kind of low

925
00:43:14,798 --> 00:43:18,400
actually there's structure and what can

926
00:43:16,929 --> 00:43:19,868
seen you in higher resolutions within

927
00:43:18,400 --> 00:43:25,160
this nebula I was just reading about it

928
00:43:19,869 --> 00:43:29,539
and so the the size of this nebula

929
00:43:25,159 --> 00:43:32,569
the star is about to power 6 which is 6

930
00:43:29,539 --> 00:43:35,090
light years so that gives you an idea of

931
00:43:32,570 --> 00:43:37,190
the scale so these stars are a few light

932
00:43:35,090 --> 00:43:42,710
years away from each other but still

933
00:43:37,190 --> 00:43:46,630
within a compact cluster and this nebula

934
00:43:42,710 --> 00:43:49,070
they are 127 injected has expanded to

935
00:43:46,630 --> 00:43:49,789
golf at star or maybe it looks pretty

936
00:43:49,070 --> 00:43:52,690
blue to me

937
00:43:49,789 --> 00:43:54,980
maybe it's in front of the nebula you

938
00:43:52,690 --> 00:43:56,329
can tell this isn't the great image too

939
00:43:54,980 --> 00:43:58,280
because as the star images we don't have

940
00:43:56,329 --> 00:43:59,630
fuzzy we don't like that that's bad

941

00:43:58,280 --> 00:44:01,280
seeing introduced by the Earth's

942
00:43:59,630 --> 00:44:02,809
atmosphere so this is an excellent

943
00:44:01,280 --> 00:44:04,250
Observatory in Chile where they have

944
00:44:02,809 --> 00:44:07,480
very good seeing some nights but not on

945
00:44:04,250 --> 00:44:07,480
this particular one yes

946
00:44:15,980 --> 00:44:23,760
sure yes that's a huge subject binary

947
00:44:21,059 --> 00:44:25,950
stars and so thank most stars are

948
00:44:23,760 --> 00:44:29,549
especially messy stars are binaries or

949
00:44:25,949 --> 00:44:31,409
malware IR multiples and so instead of a

950
00:44:29,548 --> 00:44:32,759
single star like we have in the Sun the

951
00:44:31,409 --> 00:44:34,889
planets going around it you have two

952
00:44:32,760 --> 00:44:37,980
stars going around each other or around

953
00:44:34,889 --> 00:44:40,318
their center of mass and massive stars

954
00:44:37,980 --> 00:44:41,818
like to be binaries and thus

955
00:44:40,318 --> 00:44:43,199

tremendously complicates in the state of

956

00:44:41,818 --> 00:44:45,779

evolution because when they start to

957

00:44:43,199 --> 00:44:47,548

evolve expand then the interact and and

958

00:44:45,780 --> 00:44:51,510

want to start my dump material on the

959

00:44:47,548 --> 00:44:54,509

other one and all kinds of bad things

960

00:44:51,510 --> 00:44:56,069

gonna happen good things about look at

961

00:44:54,510 --> 00:45:01,710

it but it makes the study of stellar

962

00:44:56,068 --> 00:45:07,170

evolution my heart okay well let's go in

963

00:45:01,710 --> 00:45:08,880

here now and see so I'm not going to

964

00:45:07,170 --> 00:45:12,720

show you any more images now we're going

965

00:45:08,880 --> 00:45:14,700

to see what these stars these three

966

00:45:12,719 --> 00:45:18,568

luminous blue variables are doing right

967

00:45:14,699 --> 00:45:21,838

now so first this is our first light

968

00:45:18,568 --> 00:45:24,778

curve for our 127 let's start named up

969

00:45:21,838 --> 00:45:26,719

at the top there and so the year is up

970
00:45:24,778 --> 00:45:29,460
at the top about it was Julian days and

971
00:45:26,719 --> 00:45:31,169
you can't remember what those mean but

972
00:45:29,460 --> 00:45:34,440
they're useful but you can see then that

973
00:45:31,170 --> 00:45:35,730
this sequence of measures individual

974
00:45:34,440 --> 00:45:48,829
measures of the brightness on different

975
00:45:35,730 --> 00:45:51,269
dates goes from just before 2008 to so

976
00:45:48,829 --> 00:45:53,730
this this is amazing and that was a

977
00:45:51,269 --> 00:45:56,038
little bit embarrassing because we wrote

978
00:45:53,730 --> 00:45:57,809
a paper in 2008 about the giant outburst

979
00:45:56,039 --> 00:46:00,630
of our 127 which as I said was

980
00:45:57,809 --> 00:46:02,730
discovered 1980 we studied it you know

981
00:46:00,630 --> 00:46:08,838
for almost 30 years and and then it came

982
00:46:02,730 --> 00:46:11,099
down down down down down down down

983
00:46:08,838 --> 00:46:13,920
these are points from our previous paper

984
00:46:11,099 --> 00:46:16,588
published in 2008 and so toilet paper

985
00:46:13,920 --> 00:46:19,108
was the end of the three decade outburst

986
00:46:16,588 --> 00:46:21,750
of our 127 before the paper even appear

987
00:46:19,108 --> 00:46:23,549
in press I went back up again

988
00:46:21,750 --> 00:46:25,199
and that's what they do we don't

989
00:46:23,550 --> 00:46:27,660
understand them we don't understand why

990
00:46:25,199 --> 00:46:30,329
they do this and now as opposed to this

991
00:46:27,659 --> 00:46:31,769
sort of 30 year outburst with

992
00:46:30,329 --> 00:46:32,789
fluctuations and everything which I'm

993
00:46:31,769 --> 00:46:37,219
not showing you because I can't show you

994
00:46:32,789 --> 00:46:40,500
everything I have now it's had like four

995
00:46:37,219 --> 00:46:42,839
these undulations with timescales of two

996
00:46:40,500 --> 00:46:45,179
or three years why is it doing that what

997
00:46:42,840 --> 00:46:47,460
does it mean it is this reverberation a

998

00:46:45,179 --> 00:46:49,289
reaction to what happened before or is

999
00:46:47,460 --> 00:46:51,840
this kind of going to become a supernova

1000
00:46:49,289 --> 00:46:53,579
and give us the delight that we would

1001
00:46:51,840 --> 00:46:58,349
hope it's falling apart completely and

1002
00:46:53,579 --> 00:47:00,869
will explode so that's what it's doing

1003
00:46:58,349 --> 00:47:03,809
and unfortunately I can't explain to you

1004
00:47:00,869 --> 00:47:06,150
why or how but there are obviously some

1005
00:47:03,809 --> 00:47:07,739
instabilities inside the star related to

1006
00:47:06,150 --> 00:47:11,700
the ending of the nuclear reactions and

1007
00:47:07,739 --> 00:47:13,979
these LBV excursions and that's what

1008
00:47:11,699 --> 00:47:17,039
it's doing now these marks down below

1009
00:47:13,980 --> 00:47:18,570
our epics at which we have spectrum both

1010
00:47:17,039 --> 00:47:20,340
high resolution and low resolution

1011
00:47:18,570 --> 00:47:23,220
spectra and that's what I'll show you

1012
00:47:20,340 --> 00:47:24,720

next and try to explain a little so the

1013

00:47:23,219 --> 00:47:27,329

upper ones are high resolution spectra

1014

00:47:24,719 --> 00:47:31,439

and they're low resolution so first I

1015

00:47:27,329 --> 00:47:33,719

have here a montage of these are V

1016

00:47:31,440 --> 00:47:36,809

magnitudes here so the magnitude is

1017

00:47:33,719 --> 00:47:38,608

Amino as a factor of 2.55 magnitudes is

1018

00:47:36,809 --> 00:47:40,880

a factor of 100 and brightness so so

1019

00:47:38,608 --> 00:47:43,139

this thing arranged over two magnitudes

1020

00:47:40,880 --> 00:47:44,880

during this period although it was

1021

00:47:43,139 --> 00:47:47,368

brighter than that it was like the

1022

00:47:44,880 --> 00:47:53,849

magnitude up at the top of the 1990 a

1023

00:47:47,369 --> 00:47:57,269

maximum well here is a sequence of the

1024

00:47:53,849 --> 00:48:01,170

spectra which Franca's kind of made

1025

00:47:57,269 --> 00:48:02,489

brighter so we can see the label is a

1026

00:48:01,170 --> 00:48:03,930

little better and I want to spend a

1027
00:48:02,489 --> 00:48:06,799
little time explaining them because I'm

1028
00:48:03,929 --> 00:48:08,848
sure most of you are not familiar with

1029
00:48:06,800 --> 00:48:11,250
astronomical spectra maybe not any

1030
00:48:08,849 --> 00:48:13,410
spectra and and we have a certain

1031
00:48:11,250 --> 00:48:14,880
notation so the first thing you see is

1032
00:48:13,409 --> 00:48:17,279
all these lines right

1033
00:48:14,880 --> 00:48:19,349
most of them going upwards those are

1034
00:48:17,280 --> 00:48:21,089
called emission lines actually it was

1035
00:48:19,349 --> 00:48:23,880
useful we had an introduction here about

1036
00:48:21,088 --> 00:48:25,070
a planet which cooler material produces

1037
00:48:23,880 --> 00:48:26,930
absorption and

1038
00:48:25,070 --> 00:48:29,600
produces a mission same things going on

1039
00:48:26,929 --> 00:48:30,829
here and so there are a few absorptions

1040
00:48:29,599 --> 00:48:32,360
you can say we'll see in some more

1041
00:48:30,829 --> 00:48:36,349
speculator which are dominated by

1042
00:48:32,360 --> 00:48:38,930
absorption but these are each one of

1043
00:48:36,349 --> 00:48:43,639
those lines is a transition of electrons

1044
00:48:38,929 --> 00:48:47,629
in an atom now most of you probably know

1045
00:48:43,639 --> 00:48:50,329
that some matter is made up of atoms in

1046
00:48:47,630 --> 00:48:52,340
developments and they have nuclei with

1047
00:48:50,329 --> 00:48:53,599
protons and neutrons and protons a

1048
00:48:52,340 --> 00:48:54,920
positive charge and then the neutral

1049
00:48:53,599 --> 00:48:57,469
state they have an equal number of

1050
00:48:54,920 --> 00:48:59,329
electrons to protons with negative

1051
00:48:57,469 --> 00:49:03,139
charges surrounding the nucleus so

1052
00:48:59,329 --> 00:49:04,309
they're electrically neutral electrons

1053
00:49:03,139 --> 00:49:07,429
are negative and the protons are

1054
00:49:04,309 --> 00:49:08,900
positive but a very interesting

1055

00:49:07,429 --> 00:49:11,659
important thing is if you increase the

1056
00:49:08,900 --> 00:49:15,880
temperature or decrease the pressure of

1057
00:49:11,659 --> 00:49:18,829
the gas containing this material these

1058
00:49:15,880 --> 00:49:26,289
atoms can be ionized and lose an

1059
00:49:18,829 --> 00:49:28,849
electron or two electrons or more and

1060
00:49:26,289 --> 00:49:31,929
when that happens then we call that and

1061
00:49:28,849 --> 00:49:34,039
I had known not an atom anymore and

1062
00:49:31,929 --> 00:49:35,539
furthermore its spectrum is completely

1063
00:49:34,039 --> 00:49:38,509
different all the lines which it

1064
00:49:35,539 --> 00:49:40,759
produced as an EM are gone and whole new

1065
00:49:38,510 --> 00:49:42,710
set of lines is produced by this ion

1066
00:49:40,760 --> 00:49:45,110
because the electronic states are

1067
00:49:42,710 --> 00:49:49,220
changed by the fact that there's one

1068
00:49:45,110 --> 00:49:51,230
fewer electron there and so if you get

1069
00:49:49,219 --> 00:49:52,699

transitions these electrons can be

1070

00:49:51,230 --> 00:49:55,280
different states and then they have

1071

00:49:52,699 --> 00:49:56,719
their sort of lowest States but then

1072

00:49:55,280 --> 00:50:03,170
they can get excited up to higher ones

1073

00:49:56,719 --> 00:50:06,230
and if an atom or ion absorbs a full

1074

00:50:03,170 --> 00:50:10,039
time electron can move up to a higher

1075

00:50:06,230 --> 00:50:12,860
state but then it can move down and emit

1076

00:50:10,039 --> 00:50:16,090
a photon and so electrons moving down

1077

00:50:12,860 --> 00:50:19,250
create emission lines and electrons

1078

00:50:16,090 --> 00:50:22,430
being absorbing photons produce

1079

00:50:19,250 --> 00:50:25,010
absorption so we have a continuum here

1080

00:50:22,429 --> 00:50:28,159
for each spectrum these I should say are

1081

00:50:25,010 --> 00:50:31,160
the specter of the same star believe it

1082

00:50:28,159 --> 00:50:34,599
or not taken at those dates which you

1083

00:50:31,159 --> 00:50:34,599
know you can read from the back go from

1084
00:50:35,469 --> 00:50:47,389
2008 let's take 2008 or say 2006 2008 to

1085
00:50:42,608 --> 00:50:50,420
2016 and all these huge variations that

1086
00:50:47,389 --> 00:50:57,108
you see occurred during those eight years

1087
00:50:50,420 --> 00:51:01,190
and so here at the bottom the star was

1088
00:50:57,108 --> 00:51:03,529
in a hot state and so here you see these

1089
00:51:01,190 --> 00:51:06,200
notations which are combinations of

1090
00:51:03,530 --> 00:51:09,910
letters which are the chemical element

1091
00:51:06,199 --> 00:51:12,889
Fe is iron si is silicon HG is helium

1092
00:51:09,909 --> 00:51:14,509
and is nitrogen followed by a Roman

1093
00:51:12,889 --> 00:51:17,210
numeral and the Roman numeral

1094
00:51:14,510 --> 00:51:19,940
astronomers use to denote the ionic

1095
00:51:17,210 --> 00:51:25,699
state how many electrons has it lost so

1096
00:51:19,940 --> 00:51:27,440
if it would be Roman number one you

1097
00:51:25,699 --> 00:51:28,879
don't see many ones well you see some

1098
00:51:27,440 --> 00:51:31,880
helium one okay this is neutral helium

1099
00:51:28,880 --> 00:51:35,030
but this is ionized nitrogen this is a

1100
00:51:31,880 --> 00:51:38,119
doubly ionized iron doubly ionized

1101
00:51:35,030 --> 00:51:39,500
silicon and so these are identification

1102
00:51:38,119 --> 00:51:41,539
of these features in the spectra in fact

1103
00:51:39,500 --> 00:51:42,769
- here you see this this is mainly an

1104
00:51:41,539 --> 00:51:44,630
absorption although it has a bit of

1105
00:51:42,769 --> 00:51:47,000
mission on the red edges silicon

1106
00:51:44,630 --> 00:51:50,059
absorption triplet then you see this

1107
00:51:47,000 --> 00:51:54,679
nice multiplet here of nitrogen emission

1108
00:51:50,059 --> 00:51:57,469
lines and so this tells you right away

1109
00:51:54,679 --> 00:51:59,389
by studying the lines and especially the

1110
00:51:57,469 --> 00:52:01,579
ratios of lines from successive ions

1111
00:51:59,389 --> 00:52:04,279
what the temperature and the pressure of

1112

00:52:01,579 --> 00:52:06,769
the gas of this atmosphere or envelope

1113
00:52:04,280 --> 00:52:08,750
producing them is and so and you learned

1114
00:52:06,769 --> 00:52:10,489
the chemical composition you know there

1115
00:52:08,750 --> 00:52:13,309
are all sorts of details about the

1116
00:52:10,489 --> 00:52:16,069
physics of the atmosphere or the plasma

1117
00:52:13,309 --> 00:52:17,358
that these lines are in and as an added

1118
00:52:16,070 --> 00:52:19,309
bonus you get the radial velocity

1119
00:52:17,358 --> 00:52:21,858
because the positions of the lines which

1120
00:52:19,309 --> 00:52:23,690
are in principle fixed by the structure

1121
00:52:21,858 --> 00:52:25,039
of the atom but if there's a motion

1122
00:52:23,690 --> 00:52:27,380
along the line of sight between the

1123
00:52:25,039 --> 00:52:29,509
source and you then they move in

1124
00:52:27,380 --> 00:52:31,820
wavelength and you can measure that - so

1125
00:52:29,510 --> 00:52:33,589
it's not amazing we can get all of that

1126
00:52:31,820 --> 00:52:35,780

information and you know these these

1127

00:52:33,588 --> 00:52:38,358

stars are completely unresolved their

1128

00:52:35,780 --> 00:52:40,609

points I showed you that the the ejected

1129

00:52:38,358 --> 00:52:42,319

nebula of our 127 is resolved and we can

1130

00:52:40,608 --> 00:52:44,219

stay some spatial structure and happen

1131

00:52:42,320 --> 00:52:47,579

although this information about

1132

00:52:44,219 --> 00:52:49,559

the detailed physical details of the

1133

00:52:47,579 --> 00:52:51,810

star itself come from the spectrum

1134

00:52:49,559 --> 00:52:53,880

because they're so far away that they're

1135

00:52:51,809 --> 00:52:55,309

they're just mathematical points you

1136

00:52:53,880 --> 00:53:01,289

can't get any structural information

1137

00:52:55,309 --> 00:53:03,239

from images so then I think you

1138

00:53:01,289 --> 00:53:05,579

understand the basics I hope you do any

1139

00:53:03,239 --> 00:53:07,889

questions or doubts about what I just

1140

00:53:05,579 --> 00:53:11,160

tried there briefly explain this this is

1141
00:53:07,889 --> 00:53:14,699
you know semester course in 15 minutes

1142
00:53:11,159 --> 00:53:19,139
but I think you can capture the main

1143
00:53:14,699 --> 00:53:20,909
points and so see how it changes these

1144
00:53:19,139 --> 00:53:23,519
nitrogen lines here which correspond to

1145
00:53:20,909 --> 00:53:26,909
maybe a temperature of twenty thirty

1146
00:53:23,519 --> 00:53:28,858
thousand degrees weaker disappear gone

1147
00:53:26,909 --> 00:53:30,000
no longer there now I hear all these

1148
00:53:28,858 --> 00:53:33,838
other lines over here these are

1149
00:53:30,000 --> 00:53:36,150
magnesium two iron two lines cooler from

1150
00:53:33,838 --> 00:53:38,639
a cooler atmosphere so this star is

1151
00:53:36,150 --> 00:53:41,940
cooled I mean the it's expanded and it's

1152
00:53:38,639 --> 00:53:47,190
cooled and the visual magnitude has

1153
00:53:41,940 --> 00:53:49,289
gotten brighter and and then now by the

1154
00:53:47,190 --> 00:53:52,079
sequence it's coming back here there are

1155
00:53:49,289 --> 00:53:54,599
the nitrogen two lines again showing up

1156
00:53:52,079 --> 00:53:58,560
so over these eight years we observe

1157
00:53:54,599 --> 00:54:00,720
this star or this it'll be an outburst

1158
00:53:58,559 --> 00:54:04,338
to go from a hotter state through a

1159
00:54:00,719 --> 00:54:07,318
cooler one and then back to a hotter one

1160
00:54:04,338 --> 00:54:09,599
so that's what we're doing here I can't

1161
00:54:07,318 --> 00:54:11,818
tell you why but first you have to know

1162
00:54:09,599 --> 00:54:13,260
that it does this right if you didn't

1163
00:54:11,818 --> 00:54:16,440
even know this you're never gonna figure

1164
00:54:13,260 --> 00:54:17,940
out why sometimes you have an argument

1165
00:54:16,440 --> 00:54:19,920
irritations who don't like all these

1166
00:54:17,940 --> 00:54:21,210
observational details but they like to

1167
00:54:19,920 --> 00:54:23,338
explain things that's true the only way

1168
00:54:21,210 --> 00:54:24,690
you can explain things is by physics but

1169

00:54:23,338 --> 00:54:29,219
you can't explain something you don't

1170
00:54:24,690 --> 00:54:37,130
know first you have to discover what

1171
00:54:29,219 --> 00:54:39,419
happens usually okay well onward now

1172
00:54:37,130 --> 00:54:40,440
here I'm not going to spend a lot of

1173
00:54:39,420 --> 00:54:42,329
time on these because it's too much and

1174
00:54:40,440 --> 00:54:44,929
there's in time but

1175
00:54:42,329 --> 00:54:46,858
these are some panels from

1176
00:54:44,929 --> 00:54:48,509
high-resolution spectrograms they're

1177
00:54:46,858 --> 00:54:50,909
they're much more extended in fact

1178
00:54:48,510 --> 00:54:53,099
they're taken with the shells which use

1179
00:54:50,909 --> 00:54:55,440
multiple orders and and make a

1180
00:54:53,099 --> 00:54:57,450
two-dimensional format because otherwise

1181
00:54:55,440 --> 00:55:00,510
the thing would be a mile long if it

1182
00:54:57,449 --> 00:55:05,519
were a single spectrum like those little

1183
00:55:00,510 --> 00:55:07,560

resolution ones I showed you and so the

1184

00:55:05,519 --> 00:55:10,070

neat thing about these figures which my

1185

00:55:07,559 --> 00:55:12,539

colleague Roberta gummin made is it's

1186

00:55:10,070 --> 00:55:14,849

what you have along the left edge of

1187

00:55:12,539 --> 00:55:18,358

each of them is the light curve plotted

1188

00:55:14,849 --> 00:55:20,820

vertically okay so left is brighter and

1189

00:55:18,358 --> 00:55:23,309

then the right is cooler and then you

1190

00:55:20,820 --> 00:55:26,180

can look at the spectrum and see how it

1191

00:55:23,309 --> 00:55:29,039

changes as the temperature changes and

1192

00:55:26,179 --> 00:55:30,960

so here are these nitrogen lines that I

1193

00:55:29,039 --> 00:55:32,579

was showing you and you see a lot more

1194

00:55:30,960 --> 00:55:34,740

detail they have what we call a

1195

00:55:32,579 --> 00:55:37,799

composite P Sigma profile that's

1196

00:55:34,739 --> 00:55:39,269

combines redshifted emission and the

1197

00:55:37,800 --> 00:55:41,550

blue-shifted absorption and that's a

1198
00:55:39,269 --> 00:55:46,530
signature and expanding atmosphere by

1199
00:55:41,550 --> 00:55:49,619
the way or wind and you know they are

1200
00:55:46,530 --> 00:55:51,810
you know when the thing was faint 2008

1201
00:55:49,619 --> 00:56:01,950
now it starts to get brighter they're

1202
00:55:51,809 --> 00:56:05,719
gone as I told you it's helium one is

1203
00:56:01,949 --> 00:56:10,819
even more is more sensitive you see it's

1204
00:56:05,719 --> 00:56:14,879
its strongest when when the star is

1205
00:56:10,820 --> 00:56:18,769
hottest and faintest and goes away and

1206
00:56:14,880 --> 00:56:22,320
comes back it's very strong helium

1207
00:56:18,769 --> 00:56:25,009
neutral helium mine here that does that

1208
00:56:22,320 --> 00:56:29,480
over this sequence

1209
00:56:25,010 --> 00:56:31,220
here you see sodium one but those are

1210
00:56:29,480 --> 00:56:33,139
not in the star those are interstellar

1211
00:56:31,219 --> 00:56:35,629
lines very narrow very sharp lines a

1212
00:56:33,139 --> 00:56:38,358
very low ionization in gas and space

1213
00:56:35,630 --> 00:56:44,059
between the star and us interstellar

1214
00:56:38,358 --> 00:56:46,730
lines okay

1215
00:56:44,059 --> 00:56:48,710
that's the are 127 story then I have

1216
00:56:46,730 --> 00:56:52,880
let's move on to the second object which

1217
00:56:48,710 --> 00:56:54,380
is you know they have strong

1218
00:56:52,880 --> 00:56:56,119
similarities and that's their the the

1219
00:56:54,380 --> 00:56:58,309
bottom line of this talk is a strong

1220
00:56:56,119 --> 00:56:59,780
similarities between the behaviors of

1221
00:56:58,309 --> 00:57:01,670
these objects at different epochs and

1222
00:56:59,780 --> 00:57:04,609
among different objects at comparable

1223
00:57:01,670 --> 00:57:08,090
epochs but then you look in detail and

1224
00:57:04,608 --> 00:57:11,690
they all do different things and look at

1225
00:57:08,090 --> 00:57:17,780
the dates along the top of this plot

1226

00:57:11,690 --> 00:57:19,190
does that amaze you so this is another

1227
00:57:17,780 --> 00:57:22,840
thing we discovered in the course of

1228
00:57:19,190 --> 00:57:25,119
this work Harvard University is run

1229
00:57:22,840 --> 00:57:27,140
these stars of course in our genetic

1230
00:57:25,119 --> 00:57:29,240
chemistry you can't see the mirror you

1231
00:57:27,139 --> 00:57:31,519
have to go to South America or South

1232
00:57:29,239 --> 00:57:33,459
Africa and they had telescopes down

1233
00:57:31,519 --> 00:57:35,960
there from the late 19th century

1234
00:57:33,460 --> 00:57:38,690
monitoring stars and then taking spectra

1235
00:57:35,960 --> 00:57:41,119
and recently they digitized these data

1236
00:57:38,690 --> 00:57:43,159
and put them online and we looked and lo

1237
00:57:41,119 --> 00:57:46,460
and behold our 71 which was discovered

1238
00:57:43,159 --> 00:57:47,659
as an lbv in 1970 its gap year

1239
00:57:46,460 --> 00:57:49,429
well there's nothing where Harvard

1240
00:57:47,659 --> 00:57:52,339

stopped and no one was doing anything

1241

00:57:49,429 --> 00:57:56,649

until was discovered to be an lbv and at

1242

00:57:52,340 --> 00:58:00,730

these two huge Maxima right in 1914 and

1243

00:57:56,650 --> 00:58:02,840

1939 maybe you recognize those years so

1244

00:58:00,730 --> 00:58:06,889

let's hope that this even bigger one

1245

00:58:02,840 --> 00:58:08,230

here in 2016-2017 doesn't follow that

1246

00:58:06,889 --> 00:58:10,460

same trend

1247

00:58:08,230 --> 00:58:13,309

anyway this star has been having these

1248

00:58:10,460 --> 00:58:15,440

massive outbursts during the whole 20th

1249

00:58:13,309 --> 00:58:20,029

century we had no clue until we plotted

1250

00:58:15,440 --> 00:58:24,970

up these Harvard patrol data and and now

1251

00:58:20,030 --> 00:58:28,820

it's doing this had this outburst here

1252

00:58:24,969 --> 00:58:30,739

centered around 1970s and now right now

1253

00:58:28,820 --> 00:58:32,690

as I said earlier on it's the brightest

1254

00:58:30,739 --> 00:58:34,098

star in the

1255
00:58:32,690 --> 00:58:38,780
Magellanic Clouds brighter than 9th

1256
00:58:34,099 --> 00:58:41,210
magnitude and let's look at an expansion

1257
00:58:38,780 --> 00:58:42,920
of that right hand side there and the

1258
00:58:41,210 --> 00:58:46,460
next side so this just blows up the last

1259
00:58:42,920 --> 00:58:48,318
few years so you can see what it's doing

1260
00:58:46,460 --> 00:58:51,409
and so it was down here and then this

1261
00:58:48,318 --> 00:58:53,358
huge rise and now it's kind of flat just

1262
00:58:51,409 --> 00:58:55,279
sitting up there although you can see a

1263
00:58:53,358 --> 00:58:57,230
it's like kind of a periodic variation

1264
00:58:55,280 --> 00:58:59,510
there we're working on that that may be

1265
00:58:57,230 --> 00:59:01,190
some kind of pulsation or something that

1266
00:58:59,510 --> 00:59:04,640
will tell us more about what this star

1267
00:59:01,190 --> 00:59:06,679
is doing up at this maximum but it looks

1268
00:59:04,639 --> 00:59:10,608
like about 440 days as best you can tell

1269
00:59:06,679 --> 00:59:12,019
from that information and so now that's

1270
00:59:10,608 --> 00:59:19,598
where it is right now as far as last

1271
00:59:12,019 --> 00:59:23,960
check early 2017 and so we have spectra

1272
00:59:19,599 --> 00:59:25,930
at the epochs shown below and this is

1273
00:59:23,960 --> 00:59:31,880
the most boring slide I'll show you

1274
00:59:25,929 --> 00:59:37,129
which just almost constant absorption

1275
00:59:31,880 --> 00:59:39,440
line spectrum very boring but you see

1276
00:59:37,130 --> 00:59:45,470
the years there and look at look at the

1277
00:59:39,440 --> 00:59:47,030
previous one 2010 to 2016 and so this is

1278
00:59:45,469 --> 00:59:51,858
what its spectrum looks like as it's

1279
00:59:47,030 --> 00:59:54,710
just sitting up there on that its

1280
00:59:51,858 --> 01:00:01,519
maximum and these are absorption lines

1281
00:59:54,710 --> 01:00:02,980
cool cool atmosphere iron to most of

1282
01:00:01,519 --> 01:00:08,030
their into I have identified here

1283

01:00:02,980 --> 01:00:09,409
calcium to the hydrogen lines are even

1284
01:00:08,030 --> 01:00:11,329
in a sudden we still see hydrogen lines

1285
01:00:09,409 --> 01:00:13,759
because hydrogen is the most abundant

1286
01:00:11,329 --> 01:00:16,369
element and so it forms over a large

1287
01:00:13,760 --> 01:00:19,550
range of temperatures so I'm not too

1288
01:00:16,369 --> 01:00:21,530
much interesting to see there in terms

1289
01:00:19,550 --> 01:00:23,269
of variations but of course it's

1290
01:00:21,530 --> 01:00:26,180
important to know what it's doing and

1291
01:00:23,269 --> 01:00:29,420
now it relates to the light curve here

1292
01:00:26,179 --> 01:00:32,480
are some high-resolution observations of

1293
01:00:29,420 --> 01:00:34,338
this start which go back further than

1294
01:00:32,480 --> 01:00:36,320
our monitoring we get these for archives

1295
01:00:34,338 --> 01:00:39,769
like the European Southern Observatory

1296
01:00:36,320 --> 01:00:41,530
back when it was fainter and hotter and

1297
01:00:39,769 --> 01:00:48,500

so you can see how the spectrum changes

1298

01:00:41,530 --> 01:00:51,110
just like the are 127 from hütter

1299

01:00:48,500 --> 01:00:53,389
species and at the bottom up to these

1300

01:00:51,110 --> 01:00:55,220
cooler ones that if I here but we're in

1301

01:00:53,389 --> 01:01:05,509
this light and the specter you saw of

1302

01:00:55,219 --> 01:01:07,969
iron to here's a sort of curious detail

1303

01:01:05,510 --> 01:01:09,440
if you're curious about the

1304

01:01:07,969 --> 01:01:12,109
spectroscopic details remember I told

1305

01:01:09,440 --> 01:01:13,730
you these sodium one lines are very

1306

01:01:12,110 --> 01:01:15,860
narrow that's characteristic of

1307

01:01:13,730 --> 01:01:18,019
interstellar lines and they're too low

1308

01:01:15,860 --> 01:01:19,789
ionization for these hot stellar

1309

01:01:18,019 --> 01:01:22,219
atmospheres that form there but now look

1310

01:01:19,789 --> 01:01:23,929
what happens they get strong and broad

1311

01:01:22,219 --> 01:01:26,029
that's because they're now stellar

1312
01:01:23,929 --> 01:01:28,309
features the star has gotten so cool

1313
01:01:26,030 --> 01:01:30,560
that it can form sodium neutral sodium

1314
01:01:28,309 --> 01:01:32,869
lines in its own atmosphere and so the

1315
01:01:30,559 --> 01:01:36,529
interstellar lines you can see here are

1316
01:01:32,869 --> 01:01:38,750
obliterated by the by the star itself

1317
01:01:36,530 --> 01:01:41,120
actually it's even more interesting that

1318
01:01:38,750 --> 01:01:42,920
this is a doublet two lines so you see

1319
01:01:41,119 --> 01:01:44,900
two narrow ones and two broad ones okay

1320
01:01:42,920 --> 01:01:47,510
the two narrow ones are formed in our

1321
01:01:44,900 --> 01:01:49,070
galaxy in the halo of our galaxy the two

1322
01:01:47,510 --> 01:01:50,780
broad ones are formed in the Large

1323
01:01:49,070 --> 01:01:52,670
Magellanic Cloud which has a radius is

1324
01:01:50,780 --> 01:01:54,830
shifted relative to the galaxy so you

1325
01:01:52,670 --> 01:01:58,550
can see that the stellar sodium lines

1326
01:01:54,829 --> 01:02:00,230
are shifted red shifted to the velocity

1327
01:01:58,550 --> 01:02:02,690
that star has in the large menshikov

1328
01:02:00,230 --> 01:02:04,639
where is the galactic interstellar lines

1329
01:02:02,690 --> 01:02:08,440
of course unaffected by what this star

1330
01:02:04,639 --> 01:02:13,539
is doing 170,000 light-years away hmm

1331
01:02:08,440 --> 01:02:13,539
all sorts of neat things in spectra

1332
01:02:16,030 --> 01:02:20,980
and finally I have one more star to show

1333
01:02:18,610 --> 01:02:22,990
you and very pleased with this one

1334
01:02:20,980 --> 01:02:26,920
because we have made that important

1335
01:02:22,989 --> 01:02:29,469
discovery which makes it a second our

1336
01:02:26,920 --> 01:02:32,590
127 that's its name up there from the

1337
01:02:29,469 --> 01:02:35,919
Henry Draper extension catalog to 695 a

1338
01:02:32,590 --> 01:02:38,470
- it's an LV was not really confirmed as

1339
01:02:35,920 --> 01:02:40,780
an LBV before work because there weren't

1340

01:02:38,469 --> 01:02:42,429
enough data I see big gaps there with no

1341
01:02:40,780 --> 01:02:45,250
one was interested in this star but

1342
01:02:42,429 --> 01:02:47,379
fortunately some people had observed it

1343
01:02:45,250 --> 01:02:49,980
and you see a twelfth magnitude very

1344
01:02:47,380 --> 01:02:53,140
faint and that is the magnitude that are

1345
01:02:49,980 --> 01:02:55,059
127 had I forgot to mention I studied

1346
01:02:53,139 --> 01:02:58,000
are 127 when I was on Sarah Doyle staff

1347
01:02:55,059 --> 01:02:59,650
in there in the 1970s and I discovered

1348
01:02:58,000 --> 01:03:02,199
it as a very peculiar commissioning

1349
01:02:59,650 --> 01:03:04,630
object with similar to a very small

1350
01:03:02,199 --> 01:03:06,399
number of stars are very rare and then I

1351
01:03:04,630 --> 01:03:09,460
discussed that group of stars and then

1352
01:03:06,400 --> 01:03:11,500
in 1985 it became a movie and then that

1353
01:03:09,460 --> 01:03:12,940
the first that we knew that this

1354
01:03:11,500 --> 01:03:14,889

particular class of peculiar mission

1355

01:03:12,940 --> 01:03:19,090

line stars is really quiescent state of

1356

01:03:14,889 --> 01:03:21,009

El Vivi's and again I contributed to

1357

01:03:19,090 --> 01:03:24,070

that so this star was being observed

1358

01:03:21,010 --> 01:03:26,860

here in the early 1990s and it was 12

1359

01:03:24,070 --> 01:03:29,800

magnitude and it had a spectrum like are

1360

01:03:26,860 --> 01:03:34,420

127 had before and then it did the same

1361

01:03:29,800 --> 01:03:37,690

thing 27 did and now it's bright yet

1362

01:03:34,420 --> 01:03:40,090

it's our 127 but maybe it will our 127

1363

01:03:37,690 --> 01:03:42,309

and a bunch of glitches before it got up

1364

01:03:40,090 --> 01:03:44,470

to the top and it has started going back

1365

01:03:42,309 --> 01:03:51,219

up again and so this is a light curve of

1366

01:03:44,469 --> 01:03:53,709

this star from 1990 to 2016 and of

1367

01:03:51,219 --> 01:03:56,199

course we have the spectrum and this is

1368

01:03:53,710 --> 01:03:57,880

maybe my favorite spectroscopic this one

1369
01:03:56,199 --> 01:04:04,269
is interesting the previous one was

1370
01:03:57,880 --> 01:04:08,559
boring but you see here the first one

1371
01:04:04,269 --> 01:04:11,559
which is from 1994 taken by British

1372
01:04:08,559 --> 01:04:13,150
astronomer to British astronomers one of

1373
01:04:11,559 --> 01:04:14,460
whom is here then dismiss them that Paul

1374
01:04:13,150 --> 01:04:17,920
Crowther

1375
01:04:14,460 --> 01:04:20,380
and here you see not nitrogen - as you

1376
01:04:17,920 --> 01:04:23,349
do here remember we saw that and then

1377
01:04:20,380 --> 01:04:25,260
that's like 20,000 degrees but nitrogen

1378
01:04:23,349 --> 01:04:28,139
3 it's a little bit

1379
01:04:25,260 --> 01:04:30,710
bird here but this is doubly ionized

1380
01:04:28,139 --> 01:04:37,608
nitrogen these two store lines and

1381
01:04:30,710 --> 01:04:37,608
ionized doubly ionized helium sorry

1382
01:04:37,789 --> 01:04:45,960
helium two so this means this star at

1383
01:04:44,250 --> 01:04:49,739
this epoch was much harder than it was

1384
01:04:45,960 --> 01:04:51,869
here and this is what I call a no AFP

1385
01:04:49,739 --> 01:04:54,329
size w-9 star and it is the discovery

1386
01:04:51,869 --> 01:04:57,300
that this star had that state right back

1387
01:04:54,329 --> 01:05:01,829
when it had the faint magnitude 12:19

1388
01:04:57,300 --> 01:05:04,080
remember and now it got cooler it got as

1389
01:05:01,829 --> 01:05:05,608
cool as are 127 was it being a sequence

1390
01:05:04,079 --> 01:05:07,500
I show you yeah look at this whole

1391
01:05:05,608 --> 01:05:09,769
forest here of iron - mine's a type

1392
01:05:07,500 --> 01:05:12,300
spectrum very very cool 10,000 degrees

1393
01:05:09,769 --> 01:05:14,550
so it's got 30,000 degrees twenty

1394
01:05:12,300 --> 01:05:23,100
thousand ten thousand and now it's

1395
01:05:14,550 --> 01:05:24,450
started back again it's not quite the

1396
01:05:23,099 --> 01:05:26,460
nitrogen nine-time showing up to well

1397

01:05:24,449 --> 01:05:28,739
yet that's on the way or at least it's

1398
01:05:26,460 --> 01:05:30,570
headed in that direction so we have

1399
01:05:28,739 --> 01:05:31,829
shown for the first time that this star

1400
01:05:30,570 --> 01:05:33,660
is another bonafide

1401
01:05:31,829 --> 01:05:35,489
lbv which has now been observed all away

1402
01:05:33,659 --> 01:05:38,608
from its minimum of state twelfth

1403
01:05:35,489 --> 01:05:43,739
magnitude and ana Ledo type spectrum to

1404
01:05:38,608 --> 01:05:45,469
a type spectrum near maximum and that's

1405
01:05:43,739 --> 01:05:47,639
one of the neatest things in this paper

1406
01:05:45,469 --> 01:05:49,739
because that was not previously known

1407
01:05:47,639 --> 01:05:52,079
here you see what we have in the light

1408
01:05:49,739 --> 01:05:54,689
curve and again you see the same effects

1409
01:05:52,079 --> 01:05:57,869
that unfortunate there was there was

1410
01:05:54,690 --> 01:06:00,720
almost no father no photometry here but

1411
01:05:57,869 --> 01:06:03,119

we showed that it was faint back before

1412

01:06:00,719 --> 01:06:05,159

this in the 1990s and now it's bright

1413

01:06:03,119 --> 01:06:06,960

and these are all iron - a type of

1414

01:06:05,159 --> 01:06:09,509

clients this is a forest of lines you

1415

01:06:06,960 --> 01:06:11,579

saw before in the little resolution and

1416

01:06:09,510 --> 01:06:14,250

I started to get hotter again and and

1417

01:06:11,579 --> 01:06:18,179

these lines of weaken and some higher

1418

01:06:14,250 --> 01:06:21,150

ionization lines are appearing same

1419

01:06:18,179 --> 01:06:22,679

thing same story same lines here here

1420

01:06:21,150 --> 01:06:25,320

you see the nitrogen two lines in this

1421

01:06:22,679 --> 01:06:27,449

wavelength range very clearly they're

1422

01:06:25,320 --> 01:06:29,559

disappear completely replaced by iron

1423

01:06:27,449 --> 01:06:31,659

two lines and

1424

01:06:29,559 --> 01:06:33,360

coming back to you see the helium here

1425

01:06:31,659 --> 01:06:36,399

you see the helium how it was strong

1426
01:06:33,360 --> 01:06:41,590
disappeared this is an iron mine and

1427
01:06:36,400 --> 01:06:43,680
coming back now as it gets hotter over

1428
01:06:41,590 --> 01:06:48,160
there

1429
01:06:43,679 --> 01:06:50,829
so that's what these stars do someday

1430
01:06:48,159 --> 01:06:54,519
we'll understand why and this is the

1431
01:06:50,829 --> 01:06:56,909
final I find all plot here putting all

1432
01:06:54,519 --> 01:06:59,170
of these stars and a couple other ones

1433
01:06:56,909 --> 01:07:00,250
two of which are in the paper and I'm

1434
01:06:59,170 --> 01:07:03,480
one of which isn't even in the paper

1435
01:07:00,250 --> 01:07:08,230
restaurantes on the same diagram of

1436
01:07:03,480 --> 01:07:10,420
brightness versus spectral type Oba f.g

1437
01:07:08,230 --> 01:07:12,880
the Sun is a G star the hottest stars

1438
01:07:10,420 --> 01:07:15,220
are Oh stars and DA effort intermediates

1439
01:07:12,880 --> 01:07:17,440
and so the point is this is to show that

1440
01:07:15,219 --> 01:07:19,480
you've got all these stars in this

1441
01:07:17,440 --> 01:07:22,750
diagram and they all do the same thing

1442
01:07:19,480 --> 01:07:25,210
the there's this correlation between

1443
01:07:22,750 --> 01:07:27,940
their brightness in these outbursts and

1444
01:07:25,210 --> 01:07:32,320
their temperatures or spectral types and

1445
01:07:27,940 --> 01:07:33,820
that is a very important clue to what is

1446
01:07:32,320 --> 01:07:35,710
happening the physical mechanism and we

1447
01:07:33,820 --> 01:07:38,350
don't understand and this is what has to

1448
01:07:35,710 --> 01:07:41,530
be explained how and why did I do this

1449
01:07:38,349 --> 01:07:47,409
so I actually my what my co-authors made

1450
01:07:41,530 --> 01:07:50,850
this file sign and he he kindly quoted

1451
01:07:47,409 --> 01:07:55,269
some of my prose in this slide which is

1452
01:07:50,849 --> 01:07:59,829
really the main point in conclusion of

1453
01:07:55,269 --> 01:08:11,130
this state thank you

1454

01:07:59,829 --> 01:08:11,130

[Applause]

1455

01:08:12,480 --> 01:08:25,449

okay so questions do we have any your

1456

01:08:19,960 --> 01:08:30,220

last chart shows that as they get cooler

1457

01:08:25,449 --> 01:08:32,738

they get brighter then is anything is

1458

01:08:30,220 --> 01:08:35,699

that because they're getting larger yes

1459

01:08:32,738 --> 01:08:40,389

they get brighter and visual magnitude

1460

01:08:35,699 --> 01:08:43,210

but not in there and the very first

1461

01:08:40,390 --> 01:08:44,819

slide you go back to the first one on

1462

01:08:43,210 --> 01:08:46,989

this or you just have to flow back oh

1463

01:08:44,819 --> 01:08:49,150

that's nice didn't want that that's

1464

01:08:46,988 --> 01:08:52,149

crucially they get a brighter visual

1465

01:08:49,149 --> 01:08:54,219

life because the ultraviolet energy is

1466

01:08:52,149 --> 01:08:56,738

being reprocessed by this expanding and

1467

01:08:54,220 --> 01:08:59,920

cooler envelope to lower temperatures

1468

01:08:56,738 --> 01:09:02,619

but what the chart I showed the graph of

1469

01:08:59,920 --> 01:09:05,619

the very first slide shows is that there

1470

01:09:02,619 --> 01:09:08,289

Bholu entering luminosities which is the

1471

01:09:05,619 --> 01:09:10,269

sum of all wavelengths all energy being

1472

01:09:08,289 --> 01:09:10,920

emitted by the nuclear reaction doesn't

1473

01:09:10,270 --> 01:09:13,839

change

1474

01:09:10,920 --> 01:09:19,659

see those excursion lines are flattest

1475

01:09:13,838 --> 01:09:21,609

right this is about the internet

1476

01:09:19,659 --> 01:09:24,460

generation that is changing it's not the

1477

01:09:21,609 --> 01:09:26,230

evolution if it's some structural

1478

01:09:24,460 --> 01:09:28,960

instability inside the star which is

1479

01:09:26,229 --> 01:09:31,509

causing these expansions and whatever

1480

01:09:28,960 --> 01:09:33,039

adjustments inside the star and the

1481

01:09:31,509 --> 01:09:35,909

interview generation just goes on the

1482

01:09:33,039 --> 01:09:39,369

same as it was but the visual magnitude

1483
01:09:35,909 --> 01:09:41,170
which is becomes enhanced at these

1484
01:09:39,369 --> 01:09:43,599
cooler bases and that's what I've been

1485
01:09:41,170 --> 01:09:45,760
showing you in the Lakers and so

1486
01:09:43,600 --> 01:09:47,380
very important point thank you right

1487
01:09:45,760 --> 01:09:49,930
yeah we actually had a little bit of

1488
01:09:47,380 --> 01:09:54,460
that discussion online just clarifying

1489
01:09:49,930 --> 01:09:56,050
that as they get brighter they're

1490
01:09:54,460 --> 01:09:58,060
actually getting cooler and it's dudes

1491
01:09:56,050 --> 01:10:00,730
well like the expansion and contraction

1492
01:09:58,060 --> 01:10:02,470
of the star yeah and a reprocessing of

1493
01:10:00,729 --> 01:10:05,379
the hotter radiation to lower

1494
01:10:02,470 --> 01:10:06,730
temperatures but the total amount of

1495
01:10:05,380 --> 01:10:09,279
energy emitted by the star is not

1496
01:10:06,729 --> 01:10:10,419
changing right one person wanted to know

1497
01:10:09,279 --> 01:10:13,179
if it had anything to do with solar

1498
01:10:10,420 --> 01:10:14,800
flares I I said I don't think there's

1499
01:10:13,180 --> 01:10:16,539
any national flares

1500
01:10:14,800 --> 01:10:20,020
well since we don't know if this is due

1501
01:10:16,539 --> 01:10:21,819
to as they say no but it sounds a cool

1502
01:10:20,020 --> 01:10:30,070
star the physics of cool stars it's very

1503
01:10:21,819 --> 01:10:32,439
different so many stars have some kind

1504
01:10:30,069 --> 01:10:38,710
of flares or something certainly some of

1505
01:10:32,439 --> 01:10:40,809
these ejections are not preferred axes

1506
01:10:38,710 --> 01:10:43,390
and directions so there's lots of the

1507
01:10:40,810 --> 01:10:44,950
cure physics but most likely it's no

1508
01:10:43,390 --> 01:10:46,480
that's out of question magnetic fields

1509
01:10:44,949 --> 01:10:49,300
are involved in some way good things all

1510
01:10:46,479 --> 01:10:52,929
that well it's different physics from

1511

01:10:49,300 --> 01:10:54,820
what you're having cool stars okay all

1512
01:10:52,930 --> 01:10:56,710
right pick up additional material either

1513
01:10:54,819 --> 01:10:57,639
from a neighboring star or from

1514
01:10:56,710 --> 01:10:59,350
interstellar space

1515
01:10:57,640 --> 01:11:02,200
all right so let me repeat that for the

1516
01:10:59,350 --> 01:11:04,210
online ions can stars pick up material

1517
01:11:02,199 --> 01:11:06,909
from neighboring stars we're in a

1518
01:11:04,210 --> 01:11:09,039
stellar space oh very very neighboring

1519
01:11:06,909 --> 01:11:11,409
stars namely binary companions as we

1520
01:11:09,039 --> 01:11:15,340
mentioned over here when you have two

1521
01:11:11,409 --> 01:11:17,710
stars a very close together so he starts

1522
01:11:15,340 --> 01:11:20,170
at two massive stars closer than the Sun

1523
01:11:17,710 --> 01:11:25,029
is to the earth to each other and when

1524
01:11:20,170 --> 01:11:26,680
they start to evolve and expand they was

1525
01:11:25,029 --> 01:11:28,300

expanding made up huge amounts of

1526

01:11:26,680 --> 01:11:29,860

material at the other star and actually

1527

01:11:28,300 --> 01:11:31,690

invert the mass ratio such that the

1528

01:11:29,859 --> 01:11:33,309

original star which is lower mass

1529

01:11:31,689 --> 01:11:36,449

therefore had evolved yet becomes the

1530

01:11:33,310 --> 01:11:36,450

more massive star and

1531

01:11:38,029 --> 01:12:23,489

and this variable star has been studied

1532

01:12:20,310 --> 01:12:25,289

for decades and decades as any of that

1533

01:12:23,489 --> 01:12:28,260

study produced an understanding of the

1534

01:12:25,289 --> 01:12:30,840

mechanism of the variation and is that

1535

01:12:28,260 --> 01:12:32,730

similar to or descent out in the

1536

01:12:30,840 --> 01:12:35,190

application to what's happening in the

1537

01:12:32,729 --> 01:12:37,339

blue variables okay so the question was

1538

01:12:35,189 --> 01:12:40,379

variable starts um it's time for decades

1539

01:12:37,340 --> 01:12:43,739

does that indicate what the mechanism

1540
01:12:40,380 --> 01:12:44,880
that's underneath this variability well

1541
01:12:43,739 --> 01:12:46,409
of course there may be different kinds

1542
01:12:44,880 --> 01:12:50,340
of variable stars as you probably know

1543
01:12:46,409 --> 01:12:52,649
and so they have different causes one of

1544
01:12:50,340 --> 01:12:54,119
the neatest ones it's eclipsing - and

1545
01:12:52,649 --> 01:12:57,420
these two stars going around each other

1546
01:12:54,119 --> 01:13:06,210
if they're all I'm just right with each

1547
01:12:57,420 --> 01:13:08,760
other binary stars are some of those

1548
01:13:06,210 --> 01:13:11,430
famous variable stars are pulsating

1549
01:13:08,760 --> 01:13:14,159
variable stars and there's instability

1550
01:13:11,430 --> 01:13:17,789
strips in the HR diagram which are not

1551
01:13:14,159 --> 01:13:19,680
shown here most of the effects lower

1552
01:13:17,789 --> 01:13:21,449
mass stars at cooler temperatures than

1553
01:13:19,680 --> 01:13:24,690
shown here and when they try to evolve

1554
01:13:21,449 --> 01:13:28,920
through these strips they become

1555
01:13:24,689 --> 01:13:32,629
unstable - pulsations and so they start

1556
01:13:28,920 --> 01:13:36,869
expanding and retracting periodically

1557
01:13:32,630 --> 01:13:39,630
timescales of days few days

1558
01:13:36,869 --> 01:13:41,939
and the status of those will set bids

1559
01:13:39,630 --> 01:13:43,770
and they turned out to be extremely

1560
01:13:41,939 --> 01:13:45,210
useful because they were discovered

1561
01:13:43,770 --> 01:13:47,600
early on and it was discovered that

1562
01:13:45,210 --> 01:13:51,029
their period is related to their

1563
01:13:47,600 --> 01:13:54,810
luminosity and so you can measure the

1564
01:13:51,029 --> 01:13:58,289
period very easily and their parents and

1565
01:13:54,810 --> 01:13:59,340
then the absolute not see how far away

1566
01:13:58,289 --> 01:14:01,109
they were and this is one of the main

1567
01:13:59,340 --> 01:14:05,159
ways of determining distances to

1568

01:14:01,109 --> 01:14:15,779
external galaxies through the periodic

1569
01:14:05,159 --> 01:14:19,829
stations so that's pretty well

1570
01:14:15,779 --> 01:14:21,599
understood is not what's happening here

1571
01:14:19,829 --> 01:14:25,640
that's not to say there's an emulation I

1572
01:14:21,600 --> 01:14:25,640
showed you at the top of our 71 there

1573
01:14:26,000 --> 01:14:33,439
somewhere is the outer layers of the

1574
01:14:29,310 --> 01:14:33,440
star some kind of pulsation stability as

1575
01:14:35,420 --> 01:14:39,659
these are major the adjustments inside

1576
01:14:38,039 --> 01:14:47,340
the star and not in the nuclear

1577
01:14:39,659 --> 01:14:48,689
reactions but in mass motion and those

1578
01:14:47,340 --> 01:14:59,220
are the kinds of things people think of

1579
01:14:48,689 --> 01:15:01,049
as models and our models give you a

1580
01:14:59,220 --> 01:15:04,740
question down front

1581
01:15:01,050 --> 01:15:07,260
sort of simpler the orbital periods for

1582
01:15:04,739 --> 01:15:09,719

these binaries and tidal forces play

1583

01:15:07,260 --> 01:15:11,789

role in because of this sort of acid

1584

01:15:09,720 --> 01:15:12,820

this redistribution thanks the question

1585

01:15:11,789 --> 01:15:15,159

is can antenna

1586

01:15:12,819 --> 01:15:19,960

play as stronger all this massive

1587

01:15:15,159 --> 01:15:22,590

redistribution they can and and yes they

1588

01:15:19,960 --> 01:15:24,670

can even probably even trigger outbursts

1589

01:15:22,590 --> 01:15:28,569

especially in some peculiar kinds of

1590

01:15:24,670 --> 01:15:31,060

stars so sure but just like you know the

1591

01:15:28,569 --> 01:15:33,699

moon affects their associated to form

1592

01:15:31,060 --> 01:15:35,050

the tides the same thing happens these

1593

01:15:33,699 --> 01:15:36,519

close binary stars course the closer

1594

01:15:35,050 --> 01:15:40,930

they are the more massive a rather more

1595

01:15:36,520 --> 01:15:42,160

extreme the effects and and you could

1596

01:15:40,930 --> 01:15:45,250

study this

1597
01:15:42,159 --> 01:15:47,439
there are surpassing detailed field of

1598
01:15:45,250 --> 01:15:49,329
dynamics and about how they rotate and

1599
01:15:47,439 --> 01:15:51,129
they revolve and then they get locked

1600
01:15:49,329 --> 01:15:53,920
into synchronism as the boys by the way

1601
01:15:51,130 --> 01:15:58,590
it's the same case same side faces the

1602
01:15:53,920 --> 01:15:58,590
earth and they can affect each other

1603
01:15:59,130 --> 01:16:04,930
question this is so very eccentric

1604
01:16:01,930 --> 01:16:07,000
binaries and reasons there's some

1605
01:16:04,930 --> 01:16:09,280
binaries which are very eccentric that

1606
01:16:07,000 --> 01:16:13,119
is to say they're they're almost linear

1607
01:16:09,279 --> 01:16:14,559
anything that they have and speed stars

1608
01:16:13,119 --> 01:16:17,050
increases when they're close together

1609
01:16:14,560 --> 01:16:19,360
that decreases and then increases and

1610
01:16:17,050 --> 01:16:22,570
they would by each other and these

1611
01:16:19,359 --> 01:16:24,819
periosteum passages oh very good and

1612
01:16:22,569 --> 01:16:27,309
then there can be extreme effects which

1613
01:16:24,819 --> 01:16:29,229
and some of these are binaries involving

1614
01:16:27,310 --> 01:16:32,470
neutron stars you from black holes which

1615
01:16:29,229 --> 01:16:35,079
are extremely dense and very strong

1616
01:16:32,470 --> 01:16:37,300
gravitational fields and you can get

1617
01:16:35,079 --> 01:16:38,470
some kinds of explosions and outbursts

1618
01:16:37,300 --> 01:16:42,760
and things which are triggered by

1619
01:16:38,470 --> 01:16:43,390
probably by tides periastron passages in

1620
01:16:42,760 --> 01:16:48,940
eccentric

1621
01:16:43,390 --> 01:16:51,070
miners okay I question for you is it

1622
01:16:48,939 --> 01:16:53,259
occurring considered a luminous blue

1623
01:16:51,069 --> 01:16:56,799
variable yeah that's a good question and

1624
01:16:53,260 --> 01:17:02,079
yes I know that you'll find it included

1625

01:16:56,800 --> 01:17:04,090
in the entire think about any karate is

1626
01:17:02,079 --> 01:17:05,920
because our state is a bit in great

1627
01:17:04,090 --> 01:17:08,199
detail it happens to be fairly close by

1628
01:17:05,920 --> 01:17:11,640
and then the stars that's associated

1629
01:17:08,199 --> 01:17:11,639
with which is some of the most

1630
01:17:27,930 --> 01:18:37,300
and it's especially since these LEDs and

1631
01:18:33,850 --> 01:18:40,240
in a car have these bursts that happened

1632
01:18:37,300 --> 01:18:42,489
for years and decades and you have to

1633
01:18:40,239 --> 01:18:46,389
watch them much more than the you know

1634
01:18:42,489 --> 01:18:48,969
graduate students lifetime or even more

1635
01:18:46,390 --> 01:18:51,670
than astronomers lifetime it makes it a

1636
01:18:48,970 --> 01:18:53,920
white problem it does but that

1637
01:18:51,670 --> 01:18:56,050
stimulates me to add something very

1638
01:18:53,920 --> 01:18:57,819
fascinating here we have a stronger here

1639
01:18:56,050 --> 01:19:00,730

at German astronomer's name is Armin rest

1640

01:18:57,819 --> 01:19:03,130

and he specializes in light echoes and

1641

01:19:00,729 --> 01:19:06,099

these are delayed arrival of light

1642

01:19:03,130 --> 01:19:12,250

outburst from supernovae he started

1643

01:19:06,100 --> 01:19:19,480

kurani by light scattered reflected from

1644

01:19:12,250 --> 01:19:22,840

dust clouds so he has gone on to the

1645

01:19:19,479 --> 01:19:27,129

curricula and he is discovered and

1646

01:19:22,840 --> 01:19:32,199

observed these knots first one through

1647

01:19:27,130 --> 01:19:34,869

the historical break I think we have the

1648

01:19:32,199 --> 01:19:36,939

spectrum of the elders you know there

1649

01:19:34,869 --> 01:19:39,039

were no spectrographs in 1837 when this

1650

01:19:36,939 --> 01:19:41,379

happened now with this technique we've

1651

01:19:39,039 --> 01:19:44,199

been able to go back and get the

1652

01:19:41,380 --> 01:20:18,310

spectrum Vedic Iranian outburst in 1837

1653

01:19:44,199 --> 01:20:19,840

before we had any spectrum now the

1654
01:20:18,310 --> 01:20:25,150
Europeans are building a 40 meter

1655
01:20:19,840 --> 01:20:29,710
telescope to somebody and kind of go

1656
01:20:25,149 --> 01:20:33,149
back from 200 AD before our baby

1657
01:20:29,710 --> 01:20:33,149
Never Say Never in astronomy

1658
01:20:37,149 --> 01:20:42,199
using the speed of light

1659
01:20:39,590 --> 01:20:44,690
look back in time even at something that

1660
01:20:42,199 --> 01:20:48,349
we know happened historically by looking

1661
01:20:44,689 --> 01:20:50,599
at the echoes from it so these variable

1662
01:20:48,350 --> 01:20:52,370
stars will hope will keep keeping

1663
01:20:50,600 --> 01:20:53,960
astronomers gainfully employed for quite

1664
01:20:52,369 --> 01:20:57,140
some time all right

1665
01:20:53,960 --> 01:20:58,850
next month will be our look at Cassini's

1666
01:20:57,140 --> 01:20:59,539
grand finale it's Saturn with bunny

1667
01:20:58,850 --> 01:21:04,150
monkey

1668

01:20:59,539 --> 01:21:04,149

let's give Nolan one more Hannibal car

1669

01:21:08,289 --> 01:21:15,880

thank you for coming we'll see you next

1670

01:21:10,310 --> 01:21:15,880

month you're you're a great audience

1671

01:21:43,850 --> 01:21:47,719

you're just going to