PUBLIC LECTURE SERIES

Active Luminous Blue Variables in the Large Magellanic Cloud

Featuring Guest Speaker :

Nolan Walborn

1
00:00:05,599 --> 00:00:01,910
I am dr. Frank summers of the office of

2
00:00:08,270 --> 00:00:05,609
public outreach when you came in you got

3
00:00:12,310 --> 00:00:08,280
a brand new lithograph I hope you got a

4
00:00:15,770 --> 00:00:12,320
brand new lithograph of supernova 1987a

5
00:00:18,920 --> 00:00:15,780
and this is in particular discussing

6
00:00:21,769 --> 00:00:18,930
what supernova 1987a looks like thirty

7
00:00:23,660 --> 00:00:21,779
years after the explosion there's a lot

8
00:00:26,060 --> 00:00:23,670
of things that don't change in astronomy

9
00:00:27,320 --> 00:00:26,070
over the course of a lifetime supernovae

10
00:00:29,839 --> 00:00:27,330
they're one of the things that actually

11
00:00:31,669 --> 00:00:29,849
do change over course your lifetime flip

12
00:00:33,350 --> 00:00:31,679
over on the back and you can read some

13
00:00:36,709 --> 00:00:33,360

of the changes that we have learned and

14
00:00:38,479 --> 00:00:36,719
all we still have more cool stuff that

15
00:00:41,410 --> 00:00:38,489
we're going to learn from watching

16
00:00:44,330 --> 00:00:41,420
supernovae 1980s a develop it's just

17
00:00:48,080 --> 00:00:44,340
changed from one phase into the other

18
00:00:50,029 --> 00:00:48,090
phase in around 2016 so it's a cool time

19
00:00:52,220 --> 00:00:50,039
to be watching it and we'll continue to

20
00:00:55,369 --> 00:00:52,230
watch it as long as we have telescopes

21
00:00:58,400 --> 00:00:55,379
to look at it alright tonight's talk

22
00:01:01,760 --> 00:00:58,410
will be active luminous blue variables

23
00:01:03,920 --> 00:01:01,770
in the Large Magellanic Clouds it's a

24
00:01:06,440 --> 00:01:03,930
mouthful but no one will explain it in

25
00:01:09,530 --> 00:01:06,450
great detail for you tonight

26
00:01:10,280 --> 00:01:09,540
and next month we have a really really

27
00:01:13,609 --> 00:01:10,290
cool talk

28
00:01:15,200 --> 00:01:13,619
Cassini's grand finale at Saturn and

29
00:01:17,140 --> 00:01:15,210
I'll tell you just a little bit more

30
00:01:18,289 --> 00:01:17,150
about that during the news summary

31
00:01:21,020 --> 00:01:18,299
Bonnie

32
00:01:22,060 --> 00:01:21,030
is our Saturn and Saturn ring expert

33
00:01:25,670 --> 00:01:22,070
here in the building

34
00:01:27,230 --> 00:01:25,680
so I twisted her arm actually I gave her

35
00:01:29,240 --> 00:01:27,240
no choice I said look you've just got to

36
00:01:31,310 --> 00:01:29,250
do this and she was like yeah I guess I

37
00:01:33,800 --> 00:01:31,320
got to do it okay so we'll do that and

38
00:01:35,600 --> 00:01:33,810

then November and December haven't been

39
00:01:37,039 --> 00:01:35,610
scheduled because astronomers don't

40
00:01:40,490 --> 00:01:37,049
respond to their emails over the summer

41
00:01:43,219 --> 00:01:40,500
break I'm waiting seriously I waited

42
00:01:44,719 --> 00:01:43,229
until after Labor Day and now I'm

43
00:01:46,819 --> 00:01:44,729
sending out the email tomorrow and I'll

44
00:01:50,389 --> 00:01:46,829
have those and the rest of the schedule

45
00:01:52,190 --> 00:01:50,399
filled out relatively soon if you want

46
00:01:54,740 --> 00:01:52,200
to find out about what that schedule is

47
00:01:56,389 --> 00:01:54,750
you can go to our website use your

48
00:01:58,609 --> 00:01:56,399
favorite search engine and put in Hubble

49
00:02:01,160 --> 00:01:58,619
public talks and you'll find the

50
00:02:03,260 --> 00:02:01,170
upcoming lectures listed here you can

51
00:02:05,840 --> 00:02:03,270
also watch live here are the links to

52
00:02:08,510 --> 00:02:05,850
live webcasting the archives of the

53
00:02:12,050 --> 00:02:08,520
webcasting back to over 10 years of

54
00:02:13,670 --> 00:02:12,060
talks and you can sign up for the email

55
00:02:16,610 --> 00:02:13,680
announcements which will remind you

56
00:02:19,729 --> 00:02:16,620
each month of while who's who's talking

57
00:02:22,160 --> 00:02:19,739
alright as I said the announcements you

58
00:02:25,160 --> 00:02:22,170
can sign up at the website if you do not

59
00:02:26,660 --> 00:02:25,170
like going to websites and you want to

60
00:02:30,470 --> 00:02:26,670
just hand me a piece of paper with your

61
00:02:32,240 --> 00:02:30,480
email that also works as well if you

62
00:02:35,690 --> 00:02:32,250
have comments or questions just send

63
00:02:40,449 --> 00:02:35,700

them to public lecture at STScI edu and

64
00:02:43,250 --> 00:02:40,459
I were one of my colleagues will respond

65
00:02:46,640 --> 00:02:43,260
social media we have Facebook Twitter

66
00:02:48,979 --> 00:02:46,650
YouTube and Instagram channels that are

67
00:02:51,949 --> 00:02:48,989
officially supported and have regular

68
00:02:53,929 --> 00:02:51,959
posts on them we have my stuff which is

69
00:02:57,349 --> 00:02:53,939
my blog my facebook Google and Twitter

70
00:02:58,640 --> 00:02:57,359
which are not regularly updated I in

71
00:03:00,199 --> 00:02:58,650
particular the last month I've been

72
00:03:03,530 --> 00:03:00,209
traveling a lot I don't think I've put

73
00:03:04,849 --> 00:03:03,540
anything up in the last three weeks but

74
00:03:07,280 --> 00:03:04,859
I will make up for it this month

75
00:03:10,789 --> 00:03:07,290
probably as I start to get my Eclipse

76
00:03:18,379 --> 00:03:10,799
stuff put out there guess what

77
00:03:20,089 --> 00:03:18,389
there's no observing tonight but they

78
00:03:23,569 --> 00:03:20,099
have a Maryland Space Grant consortium

79
00:03:27,490 --> 00:03:23,579
has just redone their website and they

80
00:03:30,920 --> 00:03:27,500
have Observatory status right on their a

81
00:03:33,740 --> 00:03:30,930
page for the Morris W off it telescope

82
00:03:36,289 --> 00:03:33,750
so if you go to their mate page MD dot

83
00:03:39,050 --> 00:03:36,299
space grant org click on observing

84
00:03:41,270 --> 00:03:39,060
you'll get this page and it will tell

85
00:03:42,140 --> 00:03:41,280
you what the status is for this Friday

86
00:03:46,399 --> 00:03:42,150
September

87
00:03:48,770 --> 00:03:46,409
what does that say 8 yes and it says

88
00:03:51,469 --> 00:03:48,780

check back Friday at 5:00 p.m. to find

89
00:03:53,599 --> 00:03:51,479
out if the observatory will be open ok

90
00:03:55,189 --> 00:03:53,609
so the staff will update this at 5:00

91
00:03:57,020 --> 00:03:55,199
p.m. you can come in and you can

92
00:03:58,849 --> 00:03:57,030
actually do a longer observing session

93
00:04:01,369 --> 00:03:58,859
on the Friday nights then you get to do

94
00:04:04,159 --> 00:04:01,379
after this especially tonight since you

95
00:04:06,379 --> 00:04:04,169
won't be able to do it today ok all

96
00:04:10,580 --> 00:04:06,389
right now let's do our news from the

97
00:04:14,539 --> 00:04:10,590
universe for September 2017 anybody want

98
00:04:17,949 --> 00:04:14,549
to guess what the first story is it is

99
00:04:21,979 --> 00:04:17,959
of course the Eclipse o'rama

100
00:04:25,219 --> 00:04:21,989
so the question I most got was did you

101
00:04:26,990 --> 00:04:25,229
go on vacation to see the Eclipse and my

102
00:04:29,180 --> 00:04:27,000
answer was of course

103
00:04:32,410 --> 00:04:29,190
no I did not go on vacation to see the

104
00:04:35,750 --> 00:04:32,420
Eclipse I went on vacation to see

105
00:04:39,530 --> 00:04:35,760
Yellowstone National Park and answer the

106
00:04:43,310 --> 00:04:39,540
ultimate question of where does a 2000

107
00:04:47,290 --> 00:04:43,320
pound bison walk answer is of course

108
00:04:50,630 --> 00:04:47,300
everybody together anywhere he wants

109
00:04:52,220 --> 00:04:50,640
this guy here decided he was gonna walk

110
00:04:55,040 --> 00:04:52,230
across the street and right through the

111
00:04:57,050 --> 00:04:55,050
parking lot I mean in between cars in

112
00:04:58,340 --> 00:04:57,060
the parking lot he wasn't more than 20

113
00:05:01,370 --> 00:04:58,350

feet away

114
00:05:05,360 --> 00:05:01,380
we saw some moose there's a mother moose

115
00:05:07,190 --> 00:05:05,370
and her calf eating lunch in a pond this

116
00:05:10,640 --> 00:05:07,200
is the Grand Canyon of the Yellowstone

117
00:05:14,240 --> 00:05:10,650
the Lower Falls and we saw geysers

118
00:05:15,620 --> 00:05:14,250
geysers and more geysers we had a really

119
00:05:18,110 --> 00:05:15,630
great weekend actually we left the

120
00:05:21,409 --> 00:05:18,120
geysers to last and we just got like 10

121
00:05:23,990 --> 00:05:21,419
geysers in into great eruptions in two

122
00:05:26,480 --> 00:05:24,000
days and then of course my favorite

123
00:05:30,500 --> 00:05:26,490
which we saved really till till the last

124
00:05:32,750 --> 00:05:30,510
was Grand Prismatic spring how many of

125
00:05:35,180 --> 00:05:32,760
you seen this I mean it's just so

126
00:05:37,760 --> 00:05:35,190
Technicolor you really own even-even now

127
00:05:39,610 --> 00:05:37,770
you go what's that really yeah it really

128
00:05:42,770 --> 00:05:39,620
was really the colors really are real

129
00:05:45,409 --> 00:05:42,780
and so we had a fantastic vacation in

130
00:05:48,710 --> 00:05:45,419
Yellowstone because eclipses could be

131
00:05:50,450 --> 00:05:48,720
clouded out so on the way after after we

132
00:05:54,020 --> 00:05:50,460
finished our vacation Yellowstone we

133
00:05:57,409 --> 00:05:54,030
drop down into Idaho and it was totality

134
00:06:01,070 --> 00:05:57,419
or bust as we saw in this one car in

135
00:06:04,100 --> 00:06:01,080
Idaho we went to Rexburg Idaho and they

136
00:06:07,190 --> 00:06:04,110
threw a festival they had a hundred

137
00:06:08,870 --> 00:06:07,200
tents and vendors and food trucks they

138
00:06:11,750 --> 00:06:08,880

had they gave over their whole public

139
00:06:13,930 --> 00:06:11,760
park to camping they probably had 50 to

140
00:06:18,200 --> 00:06:13,940
100 people camping out for the weekend

141
00:06:21,350 --> 00:06:18,210
and the movie theaters were very very on

142
00:06:23,150 --> 00:06:21,360
the ball they put up signs like this 3d

143
00:06:27,350 --> 00:06:23,160
glasses that this theater are not safe

144
00:06:29,659 --> 00:06:27,360
for viewing the solar eclipse the

145
00:06:32,030 --> 00:06:29,669
mini-mart had an eclipse sale for the

146
00:06:34,490 --> 00:06:32,040
three days around the Eclipse I mean it

147
00:06:37,610 --> 00:06:34,500
was just fun to have people get involved

148
00:06:39,529 --> 00:06:37,620
in it and so I being my first total

149
00:06:40,429 --> 00:06:39,539
solar eclipse I've ever seen just sat

150
00:06:43,369 --> 00:06:40,439
back

151
00:06:46,399 --> 00:06:43,379
and did not use my 3d glasses I used my

152
00:06:49,129 --> 00:06:46,409
actual solar viewing glasses and sat

153
00:06:51,529 --> 00:06:49,139
back and enjoyed it I didn't take any

154
00:06:55,009 --> 00:06:51,539
photographs but my son used his iPhone

155
00:06:56,479 --> 00:06:55,019
and he got something like that ok so I

156
00:06:59,779 --> 00:06:56,489
thought it was AI was impressed like I

157
00:07:02,179 --> 00:06:59,789
didn't I didn't even try and he was able

158
00:07:04,070 --> 00:07:02,189
to get that with his iPhone fortunately

159
00:07:06,469 --> 00:07:04,080
and I knew there would be there are

160
00:07:09,709 --> 00:07:06,479
plenty others who got some really great

161
00:07:13,459 --> 00:07:09,719
pictures including our master image

162
00:07:16,309 --> 00:07:13,469
processor here at Hubbell Zolt lavey he

163
00:07:18,350 --> 00:07:16,319

was in Jackson Hole there was an art

164
00:07:23,929 --> 00:07:18,360
exhibit of some of his photographs there

165
00:07:27,499 --> 00:07:23,939
and he got pictures like that in that

166
00:07:29,959 --> 00:07:27,509
cool so that is the corona and all the

167
00:07:33,399 --> 00:07:29,969
details and the striations of the solar

168
00:07:36,169 --> 00:07:33,409
wind blowing out away from the Sun

169
00:07:38,319 --> 00:07:36,179
result is an accomplishment and this

170
00:07:48,319 --> 00:07:38,329
right here he says is the star regulus

171
00:07:50,329 --> 00:07:48,329
ok yes yes ok so you could see about I'd

172
00:07:52,339 --> 00:07:50,339
say 60 to 70 percent of the detail he

173
00:07:55,009 --> 00:07:52,349
shows here with the naked eye which was

174
00:07:56,719 --> 00:07:55,019
really cool ok because I as a

175
00:07:59,299 --> 00:07:56,729
professional astronomer had seen

176
00:08:01,999 --> 00:07:59,309
pictures like this and I'd never seen a

177
00:08:03,859 --> 00:08:02,009
total totality before and the amount of

178
00:08:07,489 --> 00:08:03,869
detail in the striations I could see was

179
00:08:09,049 --> 00:08:07,499
surprised me huh they didn't move they

180
00:08:12,859 --> 00:08:09,059
were pretty much much much much

181
00:08:17,149 --> 00:08:12,869
stationary yes that that's Regulus

182
00:08:25,579 --> 00:08:17,159
that's Regulus I could see about 10

183
00:08:27,679 --> 00:08:25,589
stars around this guy it was just all

184
00:08:32,089 --> 00:08:27,689
started cheering and clapping and

185
00:08:37,209 --> 00:08:32,099
applause I probably didn't know what to

186
00:08:44,389 --> 00:08:41,689
Wow people were just spinning around on

187
00:08:45,310 --> 00:08:44,399
a lot of crazy pretty minutes so two

188
00:08:49,120 --> 00:08:45,320

minutes of

189
00:08:52,090 --> 00:08:49,130
in Rexburg Seoul also got pictures of

190
00:08:54,879 --> 00:08:52,100
something called Baily's beads and the

191
00:08:57,160 --> 00:08:54,889
Providence's so actually this is a

192
00:08:58,749 --> 00:08:57,170
really cool pic you can see the

193
00:09:01,060 --> 00:08:58,759
prominence on the edge of the Sun and

194
00:09:04,210 --> 00:09:01,070
down here you can start to see some a

195
00:09:07,449 --> 00:09:04,220
little bit of beading along up in here I

196
00:09:09,999 --> 00:09:07,459
couldn't see any any detail like that I

197
00:09:11,980 --> 00:09:10,009
could see individual little dots just as

198
00:09:15,879 --> 00:09:11,990
you came in and out of it but it was

199
00:09:27,970 --> 00:09:15,889
very quick and then of course you get

200
00:09:38,139 --> 00:09:27,980
the big effect this was what I remember

201
00:09:40,480 --> 00:09:38,149
most was the the Quran but as it comes

202
00:09:42,400 --> 00:09:40,490
out you watch it you gonna watch this as

203
00:09:52,689 --> 00:09:42,410
long as possible and then it starts to

204
00:09:55,120 --> 00:09:52,699
be so that's really cool I think we got

205
00:09:58,680 --> 00:09:55,130
a lot of people in America to understand

206
00:10:01,360 --> 00:09:58,690
that is really interesting which means

207
00:10:03,250 --> 00:10:01,370
that the traffic which was horrible

208
00:10:06,040 --> 00:10:03,260
getting to Salt Lake City at this time

209
00:10:10,090 --> 00:10:06,050
will be even worse next time which is

210
00:10:11,920 --> 00:10:10,100
only seven years away April 8th 2024 we

211
00:10:14,710 --> 00:10:11,930
get another four minutes total solar

212
00:10:17,680 --> 00:10:14,720
eclipse passing the peak is somewhere

213
00:10:20,860 --> 00:10:17,690

down here in Mexico it goes through just

214
00:10:23,379 --> 00:10:20,870
go to passes Austin and San Antonio go

215
00:10:28,290 --> 00:10:23,389
straight over Dallas goes all the way up

216
00:10:28,300 --> 00:11:31,040
at the intersection of the okay it's the

217
00:11:31,050 --> 00:11:39,900
[Music]

218
00:11:46,810 --> 00:11:43,509
there is another major event happening

219
00:11:50,800 --> 00:11:46,820
and this month in September is the

220
00:11:56,170 --> 00:11:50,810
Cassini climax Cassini was launched 20

221
00:11:59,439 --> 00:11:56,180
years ago almost 21 October 1997 it was

222
00:12:03,819 --> 00:11:59,449
launched and it will be crashing into

223
00:12:05,980 --> 00:12:03,829
Saturday September 15 2017 and the

224
00:12:14,769 --> 00:12:05,990
estimated signal loss will occur on

225
00:12:21,620 --> 00:12:18,310
okay all right you know if they think

226
00:12:23,269 --> 00:12:21,630
there's a tiny tiny chance it might get

227
00:12:25,280 --> 00:12:23,279
them some of us and if there's any

228
00:12:26,950 --> 00:12:25,290
prebiotic life on us all this we don't

229
00:12:29,420 --> 00:12:26,960
want to contaminate it or anything so

230
00:12:31,940 --> 00:12:29,430
like we did with other ones we're going

231
00:12:35,690 --> 00:12:31,950
to smash it crashing into the planet and

232
00:12:39,320 --> 00:12:35,700
we're gonna learn about the details of

233
00:12:41,810 --> 00:12:39,330
the planet because ask for the last

234
00:12:45,880 --> 00:12:41,820
three or four hours as it goes in we'll

235
00:12:50,269 --> 00:12:45,890
be doing a real-time data stream

236
00:13:18,160 --> 00:12:50,279
real-time data stream will be 27 per

237
00:13:22,880 --> 00:13:20,690
publicizing you'll see all sorts of cool

238
00:13:24,290 --> 00:13:22,890

stuff about it over the month see a

239
00:13:25,430 --> 00:13:24,300
little bit and Bonnie will explain to

240
00:13:30,260 --> 00:13:25,440
you what it all means

241
00:13:32,840 --> 00:13:30,270
next month one science story here

242
00:13:36,350 --> 00:13:32,850
tonight it's called into the

243
00:13:40,010 --> 00:13:36,360
stratosphere exoplanet edition now

244
00:13:42,740 --> 00:13:40,020
Earth's atmosphere is second okay we

245
00:13:44,120 --> 00:13:42,750
live and do almost everything down here

246
00:13:46,820 --> 00:13:44,130
the bottom layer of the atmosphere

247
00:13:48,170 --> 00:13:46,830
called troposphere and in the

248
00:13:50,060 --> 00:13:48,180
troposphere this is that this is a

249
00:13:52,820 --> 00:13:50,070
graphic tenant river's altitude

250
00:14:00,320 --> 00:13:52,830
temperature goes down in the troposphere

251
00:14:02,750 --> 00:14:00,330
okay but at a certain point it actually

252
00:14:05,269 --> 00:14:02,760
turns over and starts to get warmer and

253
00:14:07,940 --> 00:14:05,279
that is the layer of the atmosphere

254
00:14:10,430 --> 00:14:07,950
called the stratosphere the point is is

255
00:14:12,040 --> 00:14:10,440
we're trapping greenhouse gases are

256
00:14:15,829 --> 00:14:12,050
trying to heat down in the troposphere

257
00:14:17,190 --> 00:14:15,839
but it's being heated by the UV light in

258
00:14:19,560 --> 00:14:17,200
the status fear

259
00:14:21,360 --> 00:14:19,570
okay and then it turns over again into

260
00:14:24,450 --> 00:14:21,370
the mesosphere turn over again to the

261
00:14:25,950 --> 00:14:24,460
thermosphere and really consider the top

262
00:14:28,020 --> 00:14:25,960
the atmosphere everything else off

263
00:14:30,210 --> 00:14:28,030

here's the exosphere which is of course

264
00:14:31,950 --> 00:14:30,220
where Hubble the Space Shuttle one of

265
00:14:34,470 --> 00:14:31,960
the International Space Station are okay

266
00:14:36,540 --> 00:14:34,480
so the point is is that we understand

267
00:14:39,180 --> 00:14:36,550
first atmosphere and it's got these

268
00:14:42,030 --> 00:14:39,190
temperature inversions what we would

269
00:14:45,030 --> 00:14:42,040
want to know is are such temperature

270
00:14:47,940 --> 00:14:45,040
inversions characteristic of planets

271
00:14:50,700 --> 00:14:47,950
around other stars we see this

272
00:14:51,570 --> 00:14:50,710
temperature inversion here what happens

273
00:14:59,430 --> 00:14:51,580
on other stars

274
00:15:04,500 --> 00:14:59,440
well Hubble has a spectrum of a planet

275
00:15:06,750 --> 00:15:04,510
called was 1:21 be okay and looking at

276
00:15:09,090 --> 00:15:06,760
that they're trying to determine does it

277
00:15:12,180 --> 00:15:09,100
have a stratosphere is the are the other

278
00:15:14,760 --> 00:15:12,190
layers warmer than the inner layers if

279
00:15:17,100 --> 00:15:14,770
the other layers are cooler then they

280
00:15:19,260 --> 00:15:17,110
will actually absorb light from the

281
00:15:21,720 --> 00:15:19,270
lower layers whereas if the outer layers

282
00:15:24,060 --> 00:15:21,730
are warmer then they will emit light

283
00:15:27,330 --> 00:15:24,070
okay so you've got two graphs here this

284
00:15:30,240 --> 00:15:27,340
is purple this is a spectrum for a brown

285
00:15:32,400 --> 00:15:30,250
board that shows it if absorption okay

286
00:15:35,640 --> 00:15:32,410
so the other layers the Browns were are

287
00:15:36,870 --> 00:15:35,650
cooler they absorb and meet the water

288
00:15:39,570 --> 00:15:36,880

bands here in the infrared

289
00:15:43,230 --> 00:15:39,580
whereas Hubble spectrum actually shows

290
00:15:46,170 --> 00:15:43,240
emission at those same man passes in the

291
00:15:49,590 --> 00:15:46,180
infrared this is what they tell me the

292
00:15:52,830 --> 00:15:49,600
strong is evidence so far that they have

293
00:15:55,440 --> 00:15:52,840
seen a stratosphere on a planet around

294
00:15:57,120 --> 00:15:55,450
another star and this is the kind of

295
00:15:58,800 --> 00:15:57,130
cool thing we can look forward to over

296
00:16:01,170 --> 00:15:58,810
the next couple of decades we can

297
00:16:03,150 --> 00:16:01,180
enchant whether or not the things that

298
00:16:05,190 --> 00:16:03,160
happen in our solar system also

299
00:16:07,369 --> 00:16:05,200
happening other solar systems

300
00:16:09,889 --> 00:16:07,379
it's our solar system some house

301
00:16:11,749 --> 00:16:09,899
not because we based a lot of our

302
00:16:14,599 --> 00:16:11,759
science as scientific projections about

303
00:16:16,279 --> 00:16:14,609
the universe on our solar system but

304
00:16:16,969 --> 00:16:16,289
this is a kind of thing that shows us

305
00:16:18,949 --> 00:16:16,979
that okay

306
00:16:24,529 --> 00:16:18,959
yeah it's trap skiers also exist on

307
00:16:27,949 --> 00:16:24,539
extrasolar planets so of course a

308
00:16:30,049 --> 00:16:27,959
squiggly line is for the spectrum is not

309
00:16:32,059 --> 00:16:30,059
suitable for press release so of course

310
00:16:37,399 --> 00:16:32,069
they had to come up with a cool artist

311
00:16:40,729 --> 00:16:37,409
illustration so this is the star 121 and

312
00:16:44,509 --> 00:16:40,739
this is the planet lost 21b because it's

313
00:16:47,210 --> 00:16:44,519

so hot it's actually atmosphere is that

314
00:16:50,479 --> 00:16:47,220
around 4000 degrees they say they

315
00:16:53,749 --> 00:16:50,489
believe that the the some of the

316
00:16:55,460 --> 00:16:53,759
molecules are actually that being

317
00:16:58,369 --> 00:16:55,470
evaporated from the planet and blowing

318
00:17:00,109 --> 00:16:58,379
might be blown off in a wind but it's

319
00:17:02,419 --> 00:17:00,119
very hot in its near side that's tightly

320
00:17:05,210 --> 00:17:02,429
locked and it's actually slightly

321
00:17:07,610 --> 00:17:05,220
egg-shaped because it is filling up

322
00:17:09,799 --> 00:17:07,620
about what they said about 60% of its

323
00:17:13,039 --> 00:17:09,809
rotor flow all right the rough lobe is

324
00:17:15,350 --> 00:17:13,049
the radius at which it actually becomes

325
00:17:20,600 --> 00:17:15,360
totally descend distended and material

326
00:17:22,129 --> 00:17:20,610
and flow away freely so this is this is

327
00:17:24,949 --> 00:17:22,139
a pretty hardest conception that they

328
00:17:29,600 --> 00:17:24,959
have our artists made to show it off all

329
00:17:36,830 --> 00:17:29,610
right I am Rhonda Warren brown dwarf

330
00:17:40,039 --> 00:17:36,840
thank you I did use jargon and a star

331
00:17:42,409 --> 00:17:40,049
okay a star is powered by a

332
00:17:46,070 --> 00:17:42,419
main-sequence stars powered by hydrogen

333
00:17:48,499 --> 00:17:46,080
fusion in its core a brown dwarf reaches

334
00:17:50,299 --> 00:17:48,509
deuterium fusion but never gets big it's

335
00:17:53,180 --> 00:17:50,309
not big enough to reach hydrogen fusion

336
00:17:54,680 --> 00:17:53,190
okay a planet that Jupiter never reaches

337
00:17:57,110 --> 00:17:54,690
deuterium fusion doesn't reach any

338
00:17:58,639 --> 00:17:57,120

fusion whatsoever so the ones that make

339
00:18:02,139 --> 00:17:58,649
this tiny bit of fusion and then fade

340
00:18:08,269 --> 00:18:02,149
away those are brown dwarfs so there but

341
00:18:15,670 --> 00:18:08,279
72 per masses and above okay thank you

342
00:18:20,170 --> 00:18:15,680
for catching me on that featured speaker

343
00:18:22,540 --> 00:18:20,180
tonight is a senior scientist here and I

344
00:18:26,590 --> 00:18:22,550
guess that he'd been here about 30 years

345
00:18:28,420 --> 00:18:26,600
he said no he'd been here 34 years and

346
00:18:30,540 --> 00:18:28,430
then he said you know what I was

347
00:18:34,090 --> 00:18:30,550
actually here five years before that

348
00:18:37,300 --> 00:18:34,100
helping write the proposal that created

349
00:18:40,210 --> 00:18:37,310
this Institute okay this is a guy who's

350
00:18:42,760 --> 00:18:40,220
got so much history he was here and the

351
00:18:45,340 --> 00:18:42,770
genesis of the ideas that created this

352
00:18:47,860 --> 00:18:45,350
building okay and I gotta say you know

353
00:18:50,020 --> 00:18:47,870
this institute is was a totally new

354
00:18:52,330 --> 00:18:50,030
thing in astronomy at the time because

355
00:18:55,000 --> 00:18:52,340
most of the observatories were supported

356
00:18:57,670 --> 00:18:55,010
by staff in an astronomy department at

357
00:19:00,190 --> 00:18:57,680
some university this was an association

358
00:19:02,950 --> 00:19:00,200
of universities running a specific

359
00:19:05,710 --> 00:19:02,960
Institute to just do professional

360
00:19:08,860 --> 00:19:05,720
support of the telescope and it's turned

361
00:19:11,230 --> 00:19:08,870
out fantastically their vision has been

362
00:19:13,030 --> 00:19:11,240
executed incredibly well over the last

363
00:19:16,720 --> 00:19:13,040

thirty years

364
00:19:20,980 --> 00:19:16,730
and let's see his official status is as

365
00:19:22,870 --> 00:19:20,990
senior astronomer and it's a major

366
00:19:27,040 --> 00:19:22,880
primary support for the Space Telescope

367
00:19:29,260 --> 00:19:27,050
imaging spectrograph all right so user

368
00:19:31,450 --> 00:19:29,270
support for that okay so ladies and

369
00:19:32,790 --> 00:19:31,460
gentlemen let's have a warm welcome for

370
00:19:55,830 --> 00:19:32,800
dr. Noland Walburn

371
00:20:02,650 --> 00:20:00,010
thank you well Frank's various

372
00:20:05,590 --> 00:20:02,660
introductions here actually caused me to

373
00:20:08,080 --> 00:20:05,600
add a few preliminary additional

374
00:20:11,080 --> 00:20:08,090
introductory remarks that I wasn't going

375
00:20:12,840 --> 00:20:11,090
to first about or association of

376
00:20:15,100 --> 00:20:12,850
universities for recently astronomy

377
00:20:16,450 --> 00:20:15,110
actually it isn't true that this

378
00:20:19,120 --> 00:20:16,460
Institute was the first place that

379
00:20:21,820 --> 00:20:19,130
operated this way or found that Kitt

380
00:20:25,570 --> 00:20:21,830
Peak in Arizona and Sarah Tallulah in

381
00:20:27,370 --> 00:20:25,580
Chile the 1950s in the 1960s and these

382
00:20:29,380 --> 00:20:27,380
are the first visitor centers where

383
00:20:31,480 --> 00:20:29,390
anyone could come and observe based on

384
00:20:33,610 --> 00:20:31,490
competitive peer reviewed proposals

385
00:20:36,240 --> 00:20:33,620
instead of just people who owned the

386
00:20:38,590 --> 00:20:36,250
telescopes so or already had that

387
00:20:42,220 --> 00:20:38,600
paradigm in mind when we proposed to

388
00:20:45,780 --> 00:20:42,230

NASA to manage this incident and were

389
00:21:03,580 --> 00:20:45,790
successful against many predictions

390
00:21:07,540 --> 00:21:03,590
Princeton had which also relates to the

391
00:21:09,160 --> 00:21:07,550
live data that was distributed and also

392
00:21:11,730 --> 00:21:09,170
relates to my talk so I thought I'd say

393
00:21:14,230 --> 00:21:11,740
a couple of words about that this is

394
00:21:17,770 --> 00:21:14,240
probably most of you know is the first

395
00:21:20,800 --> 00:21:17,780
supernova this close to the Sun since

396
00:21:23,320 --> 00:21:20,810
the invention of the telescope so that

397
00:21:26,590 --> 00:21:23,330
was 1610 by the way so we're pretty

398
00:21:29,020 --> 00:21:26,600
excited about that and I'm going to be

399
00:21:32,290 --> 00:21:29,030
showing you some very peculiar

400
00:21:33,880 --> 00:21:32,300
interesting massive stars which are near

401
00:21:36,010 --> 00:21:33,890
the ends of their lifetimes and behaving

402
00:21:37,900 --> 00:21:36,020
very strangely and we don't understand

403
00:21:40,900 --> 00:21:37,910
the details of why they were doing this

404
00:21:43,060 --> 00:21:40,910
that's what we're working on but as you

405
00:21:45,790 --> 00:21:43,070
know probably all massive stars and

406
00:21:47,650 --> 00:21:45,800
their lives is super novae final

407
00:21:50,680 --> 00:21:47,660
collapse and explosion or maybe

408
00:21:52,990 --> 00:21:50,690
implosion in some very massive cases and

409
00:21:55,420 --> 00:21:53,000
yeah we would expect them to do some

410
00:21:59,500 --> 00:21:55,430
strange things before that happens about

411
00:22:01,300 --> 00:21:59,510
this one this star is only 20 solar

412
00:22:04,750 --> 00:22:01,310
masses although that's twice as massive

413
00:22:06,790 --> 00:22:04,760

as those masses that make super annoying

414
00:22:09,700 --> 00:22:06,800
and the star was known is just a normal

415
00:22:11,470 --> 00:22:09,710
ordinary blue supergiant and the LMC no

416
00:22:15,490 --> 00:22:11,480
one paid much attention to it until one

417
00:22:18,040 --> 00:22:15,500
fine day February 23rd 1987 it blew up

418
00:22:19,660 --> 00:22:18,050
and then it was too late to go back and

419
00:22:21,820 --> 00:22:19,670
study the details of the star that blew

420
00:22:24,430 --> 00:22:21,830
up we very much wish we had done that

421
00:22:26,530 --> 00:22:24,440
and but it did nothing exceptional to

422
00:22:29,790 --> 00:22:26,540
draw attention to itself until it

423
00:22:32,860 --> 00:22:29,800
exploded and that was a big surprise

424
00:22:34,600 --> 00:22:32,870
these stars will explode sometime soon

425
00:22:40,720 --> 00:22:34,610
and they are drawing attention to

426
00:22:43,150 --> 00:22:40,730
themselves so I mean this lead image

427
00:22:47,400 --> 00:22:43,160
here is the whole large magellanic cloud

428
00:22:50,350 --> 00:22:47,410
which you may know is a relatively small

429
00:22:53,220 --> 00:22:50,360
moderate sized satellite galaxy of our

430
00:22:55,750 --> 00:22:53,230
own it's very important to the study of

431
00:22:57,490 --> 00:22:55,760
many things because it is far enough

432
00:22:58,960 --> 00:22:57,500
away that we can see it as an

433
00:23:02,650 --> 00:22:58,970
independent galaxy it has its own

434
00:23:05,050 --> 00:23:02,660
evolution and heavy element content I'm

435
00:23:06,460 --> 00:23:05,060
different from our galaxy but yet it's

436
00:23:07,750 --> 00:23:06,470
near enough that with large ground-based

437
00:23:10,240 --> 00:23:07,760
telescopes in the Hubble Space Telescope

438
00:23:12,580 --> 00:23:10,250

we can study individual stars in it and

439
00:23:14,410 --> 00:23:12,590
so that's a very useful bootstrap

440
00:23:16,270 --> 00:23:14,420
between what we can do in our galaxy and

441
00:23:18,760 --> 00:23:16,280
then more distant galaxies where we

442
00:23:21,790 --> 00:23:18,770
don't have this level of resolution and

443
00:23:23,640 --> 00:23:21,800
information content so as I've already

444
00:23:27,460 --> 00:23:23,650
mentioned we've been working on these

445
00:23:28,870 --> 00:23:27,470
very peculiar variable stars and I just

446
00:23:30,880 --> 00:23:28,880
published a paper we just published a

447
00:23:32,860 --> 00:23:30,890
paper my collaborators there all of whom

448
00:23:35,590 --> 00:23:32,870
happened to be from Argentina

449
00:23:38,170 --> 00:23:35,600
I wasn't born there but I spent eight

450
00:23:40,180 --> 00:23:38,180
years there when I was a child and the

451
00:23:43,390 --> 00:23:40,190
other three are Argentines although two

452
00:23:46,020 --> 00:23:43,400
of them now work in chile las cabañas

453
00:23:48,490 --> 00:23:46,030
and la serena close to the big

454
00:23:50,200 --> 00:23:48,500
observatories like Sara toll allowing

455
00:23:51,670 --> 00:23:50,210
other ones because the climate in Chile

456
00:23:55,560 --> 00:23:51,680
is better than in Argentina for

457
00:24:00,040 --> 00:23:55,570
astronomy and so it's a hotbed of major

458
00:24:03,970 --> 00:24:00,050
international observatories they're

459
00:24:05,650 --> 00:24:03,980
still under construction so this shows

460
00:24:07,000 --> 00:24:05,660
you the location of the three objects

461
00:24:09,280 --> 00:24:07,010
and when we talking about tonight

462
00:24:10,750 --> 00:24:09,290
the paper actually involves five but

463
00:24:14,520 --> 00:24:10,760

these are the three that we have the

464
00:24:22,150 --> 00:24:14,530
most information about in our study and

465
00:24:24,310 --> 00:24:22,160
so hmm I'll start by showing a graph and

466
00:24:27,160 --> 00:24:24,320
a few images but this talk I'm going to

467
00:24:29,440 --> 00:24:27,170
show them show you mostly like curves

468
00:24:31,180 --> 00:24:29,450
that is how the brightness of these

469
00:24:32,230 --> 00:24:31,190
stars changes as a function of time in

470
00:24:35,920 --> 00:24:32,240
spectrum

471
00:24:38,350 --> 00:24:35,930
convince at least some of you by the end

472
00:24:40,180 --> 00:24:38,360
of this talk that spectra are at least

473
00:24:44,170 --> 00:24:40,190
as beautiful if not more beautiful than

474
00:24:46,990 --> 00:24:44,180
images because they tell you so much

475
00:24:49,300 --> 00:24:47,000
more you that that's how we learn the

476
00:24:52,060 --> 00:24:49,310
physics of the stars is from their

477
00:24:53,500 --> 00:24:52,070
spectra huh and so I'm gonna not gonna

478
00:24:54,430 --> 00:24:53,510
assume as some of you maybe have

479
00:24:58,300 --> 00:24:54,440
something with the area with

480
00:25:00,490 --> 00:24:58,310
spectroscopy and but I'm gonna explain

481
00:25:03,160 --> 00:25:00,500
some for those who don't and may be

482
00:25:09,070 --> 00:25:03,170
interested in that because you can learn

483
00:25:10,900 --> 00:25:09,080
a lot if you bear with me and I'll show

484
00:25:13,840 --> 00:25:10,910
you but we're starting off here with a

485
00:25:16,420 --> 00:25:13,850
graph the only graph I think I have it

486
00:25:17,560 --> 00:25:16,430
looks pretty complicated and but don't

487
00:25:19,030 --> 00:25:17,570
worry about it we're not going to talk

488
00:25:20,980 --> 00:25:19,040

about everything that's in here you can

489
00:25:26,140 --> 00:25:20,990
begin by ignoring all the red and blue

490
00:25:28,630 --> 00:25:26,150
points for something else we're

491
00:25:32,020 --> 00:25:28,640
interested in this green triangles and

492
00:25:33,550 --> 00:25:32,030
lines there but first I'm explaining

493
00:25:35,470 --> 00:25:33,560
what the diagram is this is a

494
00:25:36,640 --> 00:25:35,480
hertzsprung-russell diagram in

495
00:25:39,070 --> 00:25:36,650
particular a theoretical

496
00:25:40,750 --> 00:25:39,080
hertzsprung-russell diagram and after

497
00:25:42,160 --> 00:25:40,760
two of the most outstanding astronomers

498
00:25:44,890 --> 00:25:42,170
of the 20th century who discovered it

499
00:25:48,040 --> 00:25:44,900
and they worked with observations first

500
00:25:50,650 --> 00:25:48,050
and they may be brightnesses of the

501
00:25:52,720 --> 00:25:50,660
stars and their spectral types this has

502
00:26:00,510 --> 00:25:52,730
now been converted to temperatures these

503
00:26:07,210 --> 00:26:03,910
from 50,000 degrees

504
00:26:09,340 --> 00:26:07,220
there's hottest stars to 10,000 degrees

505
00:26:11,860 --> 00:26:09,350
so these these are all hot stars the Sun

506
00:26:14,530 --> 00:26:11,870
is 6,000 degrees so it's kind of even

507
00:26:15,330 --> 00:26:14,540
off this graph so these are massive hot

508
00:26:20,760 --> 00:26:15,340
stars

509
00:26:22,830 --> 00:26:20,770
enough they have shorter life times then

510
00:26:24,030 --> 00:26:22,840
low mass stars like the Sun because

511
00:26:26,070 --> 00:26:24,040
despite the fact that they have more

512
00:26:27,180 --> 00:26:26,080
mass the nuclear reactions are very

513
00:26:28,410 --> 00:26:27,190

sensitive to temperature they have

514
00:26:29,580 --> 00:26:28,420
higher temperatures and they burn up

515
00:26:32,910 --> 00:26:29,590
faster even though they have more

516
00:26:35,970 --> 00:26:32,920
material to burn so this bold line here

517
00:26:37,200 --> 00:26:35,980
at the left is the main sequence which

518
00:26:40,140 --> 00:26:37,210
is a very important discovery that

519
00:26:42,480 --> 00:26:40,150
hertzsprung-russell did and you put up

520
00:26:45,030 --> 00:26:42,490
all the stars in the sky that you can

521
00:26:52,260 --> 00:26:45,040
with their parameters the 90% of them

522
00:26:53,490 --> 00:26:52,270
along that line why is that well we now

523
00:26:55,230 --> 00:26:53,500
understand why that is when people

524
00:27:00,510 --> 00:26:55,240
discovered this they didn't but we made

525
00:27:02,730 --> 00:27:00,520
a lot of progress in the last decades so

526
00:27:06,930 --> 00:27:02,740
that is the locus of stars in this

527
00:27:09,180 --> 00:27:06,940
diagram of luminosity increasing upwards

528
00:27:11,490 --> 00:27:09,190
and temperature increasing leftwards

529
00:27:13,530 --> 00:27:11,500
while they are burning hydrogen into

530
00:27:16,680 --> 00:27:13,540
helium and that is 90 percent of the

531
00:27:18,090 --> 00:27:16,690
lifetime of any star and so they lie on

532
00:27:19,800 --> 00:27:18,100
this locus and that's called the

533
00:27:21,690 --> 00:27:19,810
main-sequence and here it's labeled with

534
00:27:23,850 --> 00:27:21,700
masses you see from 15 times the mass of

535
00:27:25,350 --> 00:27:23,860
the Sun up to 60 times the mass of the

536
00:27:28,140 --> 00:27:25,360
Sun and so the Stars we're talking about

537
00:27:31,440 --> 00:27:28,150
it more massive than that then then you

538
00:27:34,740 --> 00:27:31,450

see these lines drawn on here these are

539
00:27:37,230 --> 00:27:34,750
evolutionary tracks and so that's what

540
00:27:39,240 --> 00:27:37,240
the stars do in this diagram when they

541
00:27:41,400 --> 00:27:39,250
start to run out of hydrogen fuel and

542
00:27:43,950 --> 00:27:41,410
they begin to evolve as we say they

543
00:27:46,170 --> 00:27:43,960
follow these tracks in the HR diagram

544
00:27:52,890 --> 00:27:46,180
and we now understand a lot that why

545
00:27:55,620 --> 00:27:52,900
that is why they do that and they they

546
00:27:58,980 --> 00:27:55,630
take a certain length of time to evolve

547
00:28:01,590 --> 00:27:58,990
as we say and these dashed lines here

548
00:28:03,180 --> 00:28:01,600
are called isochrones and you see

549
00:28:06,150 --> 00:28:03,190
they're labeled in millions of years and

550
00:28:08,190 --> 00:28:06,160
so that tells you how far the star has

551
00:28:10,740 --> 00:28:08,200
moved away from the main sequence in

552
00:28:13,260 --> 00:28:10,750
that length of time and as I said the

553
00:28:15,690 --> 00:28:13,270
more massive stars go faster and you see

554
00:28:17,520 --> 00:28:15,700
that in two or three million years these

555
00:28:20,010 --> 00:28:17,530
star is it up here at the top are all

556
00:28:22,260 --> 00:28:20,020
the way over here but here in lower

557
00:28:23,649 --> 00:28:22,270
masses 8 or 10 million years they're

558
00:28:27,229 --> 00:28:23,659
just

559
00:28:29,210 --> 00:28:27,239
mmm still probably still burning some

560
00:28:30,919 --> 00:28:29,220
hydrogen dealing because this glitch

561
00:28:35,509 --> 00:28:30,929
here in the tracks is where they really

562
00:28:38,389 --> 00:28:35,519
run out of hydrogen well so we're

563
00:28:41,239 --> 00:28:38,399

interested in these green triangles

564
00:28:42,889 --> 00:28:41,249
which some are which are single but some

565
00:28:46,129 --> 00:28:42,899
of which they're two of joined by a

566
00:28:48,859 --> 00:28:46,139
dashed green line and that is how these

567
00:28:51,369 --> 00:28:48,869
luminous blue variables behave in in the

568
00:28:54,799 --> 00:28:51,379
HR diagram as they're undergoing

569
00:28:57,830 --> 00:28:54,809
outbursts and so these stars are so

570
00:28:59,930 --> 00:28:57,840
luminous that they can't hold themselves

571
00:29:02,749 --> 00:28:59,940
together a star is a battle between

572
00:29:04,549 --> 00:29:02,759
gravity trying to collapse it its fate

573
00:29:06,700 --> 00:29:04,559
is sealed as soon as the star forms a

574
00:29:09,229 --> 00:29:06,710
star forms from a cloud of gas in

575
00:29:11,479 --> 00:29:09,239
interstellar space that begins to

576
00:29:12,919 --> 00:29:11,489
contract and heat up and it gets hotter

577
00:29:14,779 --> 00:29:12,929
and hotter until it reaches millions of

578
00:29:16,489 --> 00:29:14,789
degrees in interiors in its interior and

579
00:29:19,669 --> 00:29:16,499
that's where nuclear reactions begin

580
00:29:22,099 --> 00:29:19,679
and so that produces a pressure outwards

581
00:29:23,869 --> 00:29:22,109
and so a star is just a huge mass of gas

582
00:29:25,279 --> 00:29:23,879
in equilibrium between gravity inwards

583
00:29:29,090 --> 00:29:25,289
and the pressure from nuclear reactions

584
00:29:30,619 --> 00:29:29,100
outwards and you can maintain that you

585
00:29:31,820 --> 00:29:30,629
have a stable star but as I already

586
00:29:34,669 --> 00:29:31,830
mentioned they don't run out of fuel

587
00:29:36,499 --> 00:29:34,679
it's burning fuel and most of its life

588
00:29:39,409 --> 00:29:36,509

time is spent the burning hydrogen the

589
00:29:41,690 --> 00:29:39,419
simplest to helium then the next atom in

590
00:29:43,460 --> 00:29:41,700
the periodic table but then it can go

591
00:29:45,710 --> 00:29:43,470
through subsequent stages where it gets

592
00:29:47,149 --> 00:29:45,720
even hotter and burns heavier elements

593
00:29:48,950 --> 00:29:47,159
and two even heavier ones and in fact

594
00:29:50,930 --> 00:29:48,960
that's very important because there are

595
00:29:52,639 --> 00:29:50,940
those nuclear reactions not only a lot

596
00:29:54,710 --> 00:29:52,649
of stars do exist but they synthesize

597
00:29:57,320 --> 00:29:54,720
all the chemical elements in the

598
00:29:58,999 --> 00:29:57,330
universe heavier than hydrogen and

599
00:30:00,499 --> 00:29:59,009
helium which come from the Big Bang a

600
00:30:02,029 --> 00:30:00,509
little bit of lithium maybe but

601
00:30:03,889 --> 00:30:02,039
everything were made out of was made

602
00:30:07,789 --> 00:30:03,899
inside of stars so the atoms and your

603
00:30:10,389 --> 00:30:07,799
way were made inside of a star or in the

604
00:30:12,440 --> 00:30:10,399
explosions the heavier elements are

605
00:30:14,509 --> 00:30:12,450
really heavy elements heavier than iron

606
00:30:16,549 --> 00:30:14,519
many of them are made in the actual

607
00:30:18,320 --> 00:30:16,559
supernova explosions when these stars

608
00:30:20,509 --> 00:30:18,330
die and then that's blown out in their

609
00:30:22,279 --> 00:30:20,519
space and new generations of stars can

610
00:30:24,560 --> 00:30:22,289
form out of that and riched material and

611
00:30:27,049 --> 00:30:24,570
the Sun is at least a second or maybe a

612
00:30:31,399 --> 00:30:27,059
third generation star because we could

613
00:30:33,529 --> 00:30:31,409

not exist with the chemical composition

614
00:30:35,420 --> 00:30:33,539
of the first stars I dream helium you

615
00:30:37,670 --> 00:30:35,430
can't make molecules

616
00:30:39,320 --> 00:30:37,680
people out of that so you need these

617
00:30:41,320 --> 00:30:39,330
heavier elements made in successive

618
00:30:45,100 --> 00:30:41,330
generation of stars in order to have

619
00:30:47,330 --> 00:30:45,110
life and everything else we have here

620
00:30:52,460 --> 00:30:47,340
well getting back to our main story here

621
00:30:54,140 --> 00:30:52,470
now these massive stars they they get

622
00:31:01,730 --> 00:30:54,150
into trouble when they try to move over

623
00:31:05,180 --> 00:31:01,740
here and they get more luminous their

624
00:31:06,740 --> 00:31:05,190
winds stars even normal massive stars

625
00:31:10,940 --> 00:31:06,750
lose material all the time through

626
00:31:13,250 --> 00:31:10,950
stellar winds but it's a steady quiet

627
00:31:14,570 --> 00:31:13,260
flow and that's okay but here then they

628
00:31:15,560 --> 00:31:14,580
start to get unstable and they can't

629
00:31:18,260 --> 00:31:15,570
hold themselves together

630
00:31:20,570 --> 00:31:18,270
so these stars have developed kind of a

631
00:31:22,100 --> 00:31:20,580
last-ditch mechanism to extend their

632
00:31:23,990 --> 00:31:22,110
lifetimes if you will which we still

633
00:31:27,350 --> 00:31:24,000
don't understand in detail in which I

634
00:31:32,720 --> 00:31:27,360
have these episodes of enhanced mass

635
00:31:37,510 --> 00:31:32,730
loss and they inflate and they become

636
00:31:40,490 --> 00:31:37,520
cooler you see them becoming cooler and

637
00:31:42,440 --> 00:31:40,500
but this is not the evolution of a

638
00:31:44,990 --> 00:31:42,450

nuclear evolution of these tracks this

639
00:31:47,350 --> 00:31:45,000
is a an event which takes place on

640
00:31:50,810 --> 00:31:47,360
timescales of thousands of years or

641
00:31:54,800 --> 00:31:50,820
hundreds of thousands of years and can

642
00:31:57,200 --> 00:31:54,810
repeat so the star gets here undergoes

643
00:31:59,510 --> 00:31:57,210
this instability moves over here and it

644
00:32:02,690 --> 00:31:59,520
moves back and it can do that several

645
00:32:05,690 --> 00:32:02,700
times with enhanced ejection of material

646
00:32:07,790 --> 00:32:05,700
and that's what a luminous blue variable

647
00:32:10,220 --> 00:32:07,800
is it's an unstable massive star near

648
00:32:11,690 --> 00:32:10,230
the end of its lifetime this dark line

649
00:32:14,990 --> 00:32:11,700
here is called the Humphreys Davidson

650
00:32:16,670 --> 00:32:15,000
limit after two astronomers who

651
00:32:19,340 --> 00:32:16,680
discovered it and found that there are

652
00:32:21,470 --> 00:32:19,350
no stars over here you go over and there

653
00:32:22,670 --> 00:32:21,480
are red stars over here but there's a

654
00:32:25,190 --> 00:32:22,680
limit that goes kind of like this and

655
00:32:27,140 --> 00:32:25,200
that and you look at the most luminous

656
00:32:29,780 --> 00:32:27,150
stars and external galaxies and no stars

657
00:32:31,490 --> 00:32:29,790
there they don't make it there they hit

658
00:32:35,840 --> 00:32:31,500
this instability limit and they do this

659
00:32:37,070 --> 00:32:35,850
and then we thought then they they lost

660
00:32:38,570 --> 00:32:37,080
a lot of material that became another

661
00:32:41,750 --> 00:32:38,580
kind of super star called the wolf or a

662
00:32:43,070 --> 00:32:41,760
star before exploding but now just

663
00:32:44,180 --> 00:32:43,080

within the last few years we have

664
00:32:45,330 --> 00:32:44,190
evidence that some of these stars

665
00:32:47,610 --> 00:32:45,340
explode directly

666
00:32:49,830 --> 00:32:47,620
as long as burials so that's our hope

667
00:32:52,650 --> 00:32:49,840
that we'll see one doing you know are a

668
00:32:54,780 --> 00:32:52,660
real block block right now and

669
00:32:56,550 --> 00:32:54,790
understanding the end stages of massive

670
00:33:00,660 --> 00:32:56,560
stars is seeing a star that we know and

671
00:33:01,890 --> 00:33:00,670
studied and will do it first thing we

672
00:33:03,630 --> 00:33:01,900
see is the supernova explosions I'm

673
00:33:05,490 --> 00:33:03,640
listen calyx and it's too late you can't

674
00:33:06,810 --> 00:33:05,500
go back and see what kind of star did

675
00:33:08,310 --> 00:33:06,820
that you can try to get some information

676
00:33:11,310 --> 00:33:08,320
some inferences maybe you have some old

677
00:33:12,480 --> 00:33:11,320
images is worth it was there but we

678
00:33:14,400 --> 00:33:12,490
would like to see one of these stars

679
00:33:16,290 --> 00:33:14,410
that we have observed doing all sorts of

680
00:33:18,810 --> 00:33:16,300
things explode and then we would know

681
00:33:20,190 --> 00:33:18,820
things that we don't know so actually

682
00:33:23,160 --> 00:33:20,200
two of the three stars I'm going to show

683
00:33:24,900 --> 00:33:23,170
you are in this diagram are 127 it's a

684
00:33:26,850 --> 00:33:24,910
red cliff for South Africa where they

685
00:33:28,080 --> 00:33:26,860
describe some of the stars they're there

686
00:33:29,760 --> 00:33:28,090
in the Magellanic Cloud the Large

687
00:33:31,650 --> 00:33:29,770
Magellanic Cloud are 127 it's been

688
00:33:33,750 --> 00:33:31,660

observed to have this huge excursion

689
00:33:35,820 --> 00:33:33,760
here from you know 30 thousand degrees

690
00:33:39,060 --> 00:33:35,830
down to ten thousand degrees and back

691
00:33:40,830 --> 00:33:39,070
again and r71 and you don't want to

692
00:33:42,030 --> 00:33:40,840
believe the plot that's this little line

693
00:33:45,660 --> 00:33:42,040
here you don't believe that too much

694
00:33:47,970 --> 00:33:45,670
because it looks like it had lower and

695
00:33:49,470 --> 00:33:47,980
when I say lower mass but it's now an

696
00:33:51,270 --> 00:33:49,480
outburst it's the brightest star in the

697
00:33:54,060 --> 00:33:51,280
large emergent that cloud right now and

698
00:33:56,820 --> 00:33:54,070
I'll show you that and it's moved up as

699
00:33:59,190 --> 00:33:56,830
opposed to horizontally as these stars

700
00:34:03,180 --> 00:33:59,200
do and so you know there's always new

701
00:34:09,210 --> 00:34:03,190
stuff to discover and then try to

702
00:34:10,920 --> 00:34:09,220
understand in astronomy so now some of

703
00:34:12,570 --> 00:34:10,930
this is kind of technical and difficult

704
00:34:13,770 --> 00:34:12,580
and I'm really trying to do my best to

705
00:34:16,200 --> 00:34:13,780
explain without jargon but if I don't

706
00:34:18,750 --> 00:34:16,210
succeed I welcome a question or a

707
00:34:20,310 --> 00:34:18,760
clarification as I'm talking any more

708
00:34:21,540 --> 00:34:20,320
extended discussion let's save that for

709
00:34:23,550 --> 00:34:21,550
the end because otherwise I won't get

710
00:34:25,530 --> 00:34:23,560
through it but if I use a term or

711
00:34:26,880 --> 00:34:25,540
something or said something that isn't

712
00:34:29,130 --> 00:34:26,890
clear and you think can be clarified

713
00:34:42,550 --> 00:34:29,140

with a few words please do like here's

714
00:34:48,010 --> 00:34:45,230
very we have obviously observed money

715
00:34:52,070 --> 00:34:48,020
for thousands of years yet but they have

716
00:34:53,450 --> 00:34:52,080
both outbursts and eruptions and I'm

717
00:34:55,730 --> 00:34:53,460
gonna be talking about outbursts mainly

718
00:34:57,830 --> 00:34:55,740
which are these things that last decades

719
00:35:01,460 --> 00:34:57,840
maybe and we have observed the full

720
00:35:02,960 --> 00:35:01,470
cycle for one we had and I'm going to

721
00:35:04,730 --> 00:35:02,970
show you for the first time most people

722
00:35:06,020 --> 00:35:04,740
didn't see it the last month paper again

723
00:35:08,440 --> 00:35:06,030
right the second one which is observed

724
00:35:11,720 --> 00:35:08,450
over the full range of outbursts but

725
00:35:15,920 --> 00:35:11,730
then they more infrequently have giant

726
00:35:17,510 --> 00:35:15,930
eruptions in which they eject much more

727
00:35:23,300 --> 00:35:17,520
and denser material and create

728
00:35:25,160 --> 00:35:23,310
circumstellar nebulae and we we've

729
00:35:28,250 --> 00:35:25,170
observed some of those events probably

730
00:35:30,290 --> 00:35:28,260
but more than that we can observe such

731
00:35:30,830 --> 00:35:30,300
events ejected the thousands of years

732
00:35:36,170 --> 00:35:30,840
ago

733
00:35:39,770 --> 00:35:36,180
were ejected and that's where that

734
00:35:48,760 --> 00:35:39,780
thousands of years comment comes from so

735
00:35:51,920 --> 00:35:48,770
it's a good question why does it go back

736
00:35:59,420 --> 00:35:56,319
oh the this little glitch here yes

737
00:36:03,049 --> 00:35:59,430
that's that's the terminal age main

738
00:36:04,970 --> 00:36:03,059

sequence and that's where really the

739
00:36:08,059 --> 00:36:04,980
helium the hydrogen burning stops

740
00:36:10,069 --> 00:36:08,069
completely and so you know this again

741
00:36:12,170 --> 00:36:10,079
this is a plot of brightness versus

742
00:36:15,079 --> 00:36:12,180
temperature so when stars get to that

743
00:36:17,240 --> 00:36:15,089
point they they do a little retrograde

744
00:36:20,690 --> 00:36:17,250
is that's a good word for it a little

745
00:36:22,430 --> 00:36:20,700
glitch in this diagram and that's as

746
00:36:25,760 --> 00:36:22,440
their interiors readjust and then they

747
00:36:27,740 --> 00:36:25,770
cross especially these Lord masses they

748
00:36:29,900 --> 00:36:27,750
cross this pretty rapidly and then they

749
00:36:31,490 --> 00:36:29,910
go over here become red giants and red

750
00:36:35,089 --> 00:36:31,500
supergiant's where they've been burn

751
00:36:36,829 --> 00:36:35,099
helium into carbon and that that can

752
00:36:41,059 --> 00:36:36,839
last the 10% of the hydrogen brain

753
00:36:44,420 --> 00:36:41,069
lifetime million years started last ten

754
00:36:47,420 --> 00:36:44,430
million years and so this is part of the

755
00:36:50,000 --> 00:36:47,430
readjustment of the Stars interior as it

756
00:36:52,250 --> 00:36:50,010
goes from losing its hydrogen source to

757
00:36:53,750 --> 00:36:52,260
gaining its helium source but and then

758
00:36:56,390 --> 00:36:53,760
it can go on and burn carbon and then

759
00:36:58,400 --> 00:36:56,400
burn the various elements up to silicon

760
00:37:01,870 --> 00:36:58,410
the most massive stars that last three

761
00:37:04,069 --> 00:37:01,880
days so they run out of tricks and then

762
00:37:06,170 --> 00:37:04,079
there's the final collapse because the

763
00:37:13,940 --> 00:37:06,180

energy goes away but the gravity is

764
00:37:15,760 --> 00:37:13,950
always there okay well let's move on I'm

765
00:37:20,359 --> 00:37:15,770
not gonna spend this much time on all

766
00:37:22,370 --> 00:37:20,369
grams I hope so first object were going

767
00:37:24,410 --> 00:37:22,380
to blur is are 127 which you heard about

768
00:37:26,120 --> 00:37:24,420
then saw it's located near 30 artists

769
00:37:28,880 --> 00:37:26,130
those of you who've been here a lot

770
00:37:30,230 --> 00:37:28,890
before hundreds on my previous talks are

771
00:37:31,940 --> 00:37:30,240
familiar with 32 right us this is a

772
00:37:34,250 --> 00:37:31,950
third Ross region action that those

773
00:37:36,589 --> 00:37:34,260
nebula is half off the screen here it's

774
00:37:38,299 --> 00:37:36,599
appear because that's not what we're

775
00:37:40,309 --> 00:37:38,309
talking about today this is the site of

776
00:37:42,710 --> 00:37:40,319
formation of the most massive star is

777
00:37:44,089 --> 00:37:42,720
known at the prison time up to 300 solar

778
00:37:46,130 --> 00:37:44,099
masses we didn't know until very

779
00:37:47,900 --> 00:37:46,140
recently that can be stars that massive

780
00:37:49,819 --> 00:37:47,910
but you see all these different kinds of

781
00:37:52,670 --> 00:37:49,829
structures here's some with nebulosity

782
00:37:54,319 --> 00:37:52,680
some without these are all massive stars

783
00:37:56,450 --> 00:37:54,329
of different masses and angels if all

784
00:37:58,279 --> 00:37:56,460
thing doing their thing in this large

785
00:37:59,060 --> 00:37:58,289
region and and if we understood why

786
00:38:01,400 --> 00:37:59,070
every star

787
00:38:02,630 --> 00:38:01,410
where is and these nebulosity so much

788
00:38:04,880 --> 00:38:02,640

you're ejected and some of which are

789
00:38:06,200 --> 00:38:04,890
just fluorescing we would know a lot

790
00:38:07,940 --> 00:38:06,210
more than we do today and someday we

791
00:38:10,820 --> 00:38:07,950
will that's is what we study and in

792
00:38:12,530 --> 00:38:10,830
particular we study our 127 which I can

793
00:38:17,360 --> 00:38:12,540
have in mark but I can point out to you

794
00:38:20,870 --> 00:38:17,370
again this Oh supernova 1987a by the way

795
00:38:22,910 --> 00:38:20,880
is right there oh and I forgot another

796
00:38:26,240 --> 00:38:22,920
thing I was gonna mention you see in

797
00:38:28,370 --> 00:38:26,250
your diagram here the supernova 87a is

798
00:38:30,860 --> 00:38:28,380
is inside that ring the famous ring

799
00:38:34,700 --> 00:38:30,870
there are two stars beside it those are

800
00:38:37,280 --> 00:38:34,710
called stars 2 and 3 and the original

801
00:38:39,380 --> 00:38:37,290
star that exploded is star one and it

802
00:38:41,780 --> 00:38:39,390
was originally three magnitudes brighter

803
00:38:43,640 --> 00:38:41,790
than those other two stars it was twelve

804
00:38:45,290 --> 00:38:43,650
nine to those two or fifteen that's a

805
00:38:46,870 --> 00:38:45,300
factor of sixteen in brightness so you

806
00:38:49,130 --> 00:38:46,880
can believe it's not there anymore right

807
00:38:51,890 --> 00:38:49,140
what we see there in the middle is just

808
00:38:54,830 --> 00:38:51,900
the blast wave from the explosion coming

809
00:38:56,270 --> 00:38:54,840
out but that star is gone so we know

810
00:38:58,340 --> 00:38:56,280
that but there was initially some

811
00:38:59,840 --> 00:38:58,350
confusion about which star had exploded

812
00:39:03,980 --> 00:38:59,850
and how many stars there were there and

813
00:39:06,110 --> 00:39:03,990

I actually discovered star 3 when the

814
00:39:08,840 --> 00:39:06,120
fader one down here just as a bulge on

815
00:39:10,760 --> 00:39:08,850
the overexposed image of the star that

816
00:39:13,850 --> 00:39:10,770
exploded in pre explosion images I had

817
00:39:17,160 --> 00:39:13,860
of theater artists back when I was on

818
00:39:22,769 --> 00:39:20,160
and I got some credit for there was a

819
00:39:24,990 --> 00:39:22,779
telegram came out say oh that because

820
00:39:27,180 --> 00:39:25,000
there are still two stars there yes

821
00:39:28,859 --> 00:39:27,190
there's still two stars there but not

822
00:39:31,710 --> 00:39:28,869
that one Wow

823
00:39:38,450 --> 00:39:31,720
so here this is a fantastic region as it

824
00:39:44,160 --> 00:39:41,579
here is this little group of stars here

825
00:39:45,660 --> 00:39:44,170
I want you to see two bright stars and

826
00:39:46,440 --> 00:39:45,670
then two fainted once I put an angle

827
00:39:50,190 --> 00:39:46,450
there okay

828
00:39:51,359 --> 00:39:50,200
and the one here in the the bright star

829
00:39:59,700 --> 00:39:51,369
of the brighter star to the right is our

830
00:40:01,500 --> 00:39:59,710
127 current behavior and but that's

831
00:40:03,839 --> 00:40:01,510
where it lies you see it's an evolved

832
00:40:06,390 --> 00:40:03,849
region okay the youngest regions have

833
00:40:08,130 --> 00:40:06,400
all gas and dust here these stars have

834
00:40:10,109 --> 00:40:08,140
evolved they've blown it all the way it

835
00:40:12,269 --> 00:40:10,119
looks like almost like a ring of stars

836
00:40:13,589 --> 00:40:12,279
here and you just tell by looking at

837
00:40:15,720 --> 00:40:13,599
these are older stars than the one

838
00:40:17,880 --> 00:40:15,730

thirty or on us because they've blown

839
00:40:22,859 --> 00:40:17,890
away all the gas and dust that they had

840
00:40:24,870 --> 00:40:22,869
around them after they formed but this

841
00:40:27,120 --> 00:40:24,880
is a low-resolution large field thing

842
00:40:29,579 --> 00:40:27,130
which a major which is useful to have

843
00:40:33,329 --> 00:40:29,589
but we want to know more we want higher

844
00:40:34,769 --> 00:40:33,339
resolution and more detail and so here

845
00:40:37,829 --> 00:40:34,779
are those same stars I just showed you

846
00:40:39,329 --> 00:40:37,839
and in a higher resolution image now

847
00:40:42,870 --> 00:40:39,339
what looked like the two brighter stars

848
00:40:44,400 --> 00:40:42,880
are actually these two clusters they

849
00:40:46,710 --> 00:40:44,410
weren't single stars and that's a big

850
00:40:50,009 --> 00:40:46,720
problem even that dark spot which is a

851
00:40:52,319 --> 00:40:50,019
nearest neighbor it's really a single

852
00:40:53,609 --> 00:40:52,329
star or just two or more stars so close

853
00:40:54,749 --> 00:40:53,619
together that we can't resolve them and

854
00:40:57,529 --> 00:40:54,759
so we're always looking for higher

855
00:41:00,509 --> 00:40:57,539
resolution to answer that question so

856
00:41:02,910 --> 00:41:00,519
you can see so these are kind of quiet

857
00:41:05,130 --> 00:41:02,920
sand blue stars and these clusters some

858
00:41:08,130 --> 00:41:05,140
brighter ones some fainter ones and but

859
00:41:11,220 --> 00:41:08,140
here is our 127 itself surrounded by

860
00:41:14,370 --> 00:41:11,230
this red halo and I didn't put that

861
00:41:18,900 --> 00:41:14,380
there it's there drawing attention to

862
00:41:21,029 --> 00:41:18,910
itself and actually when it had its

863
00:41:22,140 --> 00:41:21,039

major outburst which I also helped

864
00:41:27,089 --> 00:41:22,150
discover and

865
00:41:29,609 --> 00:41:27,099
in 80 it became much brighter than this

866
00:41:31,230 --> 00:41:29,619
star I went down to start to observe

867
00:41:33,660 --> 00:41:31,240
after I left the staff and I went to the

868
00:41:35,640 --> 00:41:33,670
field and I sat there for a while and

869
00:41:37,019 --> 00:41:35,650
see how I figured out what was going on

870
00:41:38,220 --> 00:41:37,029
it's because the field was completely

871
00:41:39,450 --> 00:41:38,230
different from what had been the last

872
00:41:41,400 --> 00:41:39,460
time I looked at it and it's because

873
00:41:42,599 --> 00:41:41,410
this star which had been the brightest

874
00:41:45,210 --> 00:41:42,609
was no longer the brightest then this

875
00:41:48,630 --> 00:41:45,220
one was way brighter by several

876
00:41:50,720 --> 00:41:48,640
magnitudes what this red glow is this is

877
00:41:52,980 --> 00:41:50,730
a sample of one of these circumstellar

878
00:41:55,019 --> 00:41:52,990
shells that was ejected there a few

879
00:41:58,079 --> 00:41:55,029
thousand years ago maybe and it is

880
00:41:59,460 --> 00:41:58,089
glowing in the light of nebula emission

881
00:42:02,579 --> 00:41:59,470
lines of hydrogen alpha but also

882
00:42:05,579 --> 00:42:02,589
especially nitrogen which is too strong

883
00:42:08,970 --> 00:42:05,589
lines on either side of each alpha and

884
00:42:10,769 --> 00:42:08,980
this these stars these massive stars

885
00:42:12,660 --> 00:42:10,779
they they undergo nuclear reactions I

886
00:42:14,279 --> 00:42:12,670
can't give you all detail of massive

887
00:42:17,519 --> 00:42:14,289
star evolution in the time I have but

888
00:42:20,670 --> 00:42:17,529

massive stars burn helium to hydrogen on

889
00:42:22,289 --> 00:42:20,680
what's hydrogen to helium on what's

890
00:42:25,170 --> 00:42:22,299
called the CNO cycle it's a series of

891
00:42:26,819 --> 00:42:25,180
reactions which very rapidly lock up all

892
00:42:29,460 --> 00:42:26,829
of the carbon nitrogen oxygen in

893
00:42:31,410 --> 00:42:29,470
nitrogen because that's the slowest

894
00:42:33,240 --> 00:42:31,420
reaction it's a bottleneck now this

895
00:42:35,700 --> 00:42:33,250
material gets mixed up to the surface of

896
00:42:37,859 --> 00:42:35,710
the star or rejected before the reaction

897
00:42:39,260 --> 00:42:37,869
go to completion you can see that and so

898
00:42:41,910 --> 00:42:39,270
you can actually see the nuclear

899
00:42:44,609 --> 00:42:41,920
reaction products of a given star on its

900
00:42:46,589 --> 00:42:44,619
own surface isn't that amazing and that

901
00:42:50,329 --> 00:42:46,599
tells you of course I don't amount about

902
00:42:55,170 --> 00:42:50,339
what star is doing how its evolving and

903
00:42:58,019 --> 00:42:55,180
yes far away from the other stars of the

904
00:42:59,940 --> 00:42:58,029
cluster is our 127 maybe just the other

905
00:43:05,099 --> 00:42:59,950
star right next to it I know we can't

906
00:43:08,900 --> 00:43:05,109
really see the depth there yeah a few a

907
00:43:11,160 --> 00:43:08,910
few parts that I happen to know that the

908
00:43:12,450 --> 00:43:11,170
this is actually I said it's high

909
00:43:14,789 --> 00:43:12,460
resolution range and it is higher than

910
00:43:16,920 --> 00:43:14,799
the previous one but it's kind of low

911
00:43:18,390 --> 00:43:16,930
actually there's structure and what can

912
00:43:19,859 --> 00:43:18,400
seen you in higher resolutions within

913
00:43:25,150 --> 00:43:19,869

this nebula I was just reading about it

914
00:43:29,530 --> 00:43:25,160
and so the the size of this nebula

915
00:43:32,560 --> 00:43:29,540
the star is about to power 6 which is 6

916
00:43:35,080 --> 00:43:32,570
light years so that gives you an idea of

917
00:43:37,180 --> 00:43:35,090
the scale so these stars are a few light

918
00:43:42,700 --> 00:43:37,190
years away from each other but still

919
00:43:46,620 --> 00:43:42,710
within a compact cluster and this nebula

920
00:43:49,060 --> 00:43:46,630
they are 127 injected has expanded to

921
00:43:49,780 --> 00:43:49,070
golf at star or maybe it looks pretty

922
00:43:52,680 --> 00:43:49,790
blue to me

923
00:43:54,970 --> 00:43:52,690
maybe it's in front of the nebula you

924
00:43:56,320 --> 00:43:54,980
can tell this isn't the great image too

925
00:43:58,270 --> 00:43:56,330
because as the star images we don't have

926
00:43:59,620 --> 00:43:58,280
fuzzy we don't like that that's bad

927
00:44:01,270 --> 00:43:59,630
seeing introduced by the Earth's

928
00:44:02,800 --> 00:44:01,280
atmosphere so this is an excellent

929
00:44:04,240 --> 00:44:02,810
Observatory in Chile where they have

930
00:44:15,970 --> 00:44:04,250
very good seeing some nights but not on

931
00:44:23,750 --> 00:44:21,049
sure yes that's a huge subject binary

932
00:44:25,940 --> 00:44:23,760
stars and so thank most stars are

933
00:44:29,539 --> 00:44:25,950
especially messy stars are binaries or

934
00:44:31,400 --> 00:44:29,549
malware IR multiples and so instead of a

935
00:44:32,750 --> 00:44:31,410
single star like we have in the Sun the

936
00:44:34,880 --> 00:44:32,760
planets going around it you have two

937
00:44:37,970 --> 00:44:34,890
stars going around each other or around

938
00:44:40,309 --> 00:44:37,980

their center of mass and massive stars

939
00:44:41,809 --> 00:44:40,319
like to be binaries and thus

940
00:44:43,190 --> 00:44:41,819
tremendously complicates in the state of

941
00:44:45,770 --> 00:44:43,200
evolution because when they start to

942
00:44:47,539 --> 00:44:45,780
evolve expand then the interact and and

943
00:44:51,500 --> 00:44:47,549
want to start my dump material on the

944
00:44:54,500 --> 00:44:51,510
other one and all kinds of bad things

945
00:44:56,059 --> 00:44:54,510
gonna happen good things about look at

946
00:45:01,700 --> 00:44:56,069
it but it makes the study of stellar

947
00:45:07,160 --> 00:45:01,710
evolution my heart okay well let's go in

948
00:45:08,870 --> 00:45:07,170
here now and see so I'm not going to

949
00:45:12,710 --> 00:45:08,880
show you any more images now we're going

950
00:45:14,690 --> 00:45:12,720
to see what these stars these three

951
00:45:18,559 --> 00:45:14,700
luminous blue variables are doing right

952
00:45:21,829 --> 00:45:18,569
now so first this is our first light

953
00:45:24,769 --> 00:45:21,839
curve for our 127 let's start named up

954
00:45:26,710 --> 00:45:24,779
at the top there and so the year is up

955
00:45:29,450 --> 00:45:26,720
at the top about it was Julian days and

956
00:45:31,160 --> 00:45:29,460
you can't remember what those mean but

957
00:45:34,430 --> 00:45:31,170
they're useful but you can see then that

958
00:45:35,720 --> 00:45:34,440
this sequence of measures individual

959
00:45:48,819 --> 00:45:35,730
measures of the brightness on different

960
00:45:51,260 --> 00:45:48,829
dates goes from just before 2008 to so

961
00:45:53,720 --> 00:45:51,270
this this is amazing and that was a

962
00:45:56,029 --> 00:45:53,730
little bit embarrassing because we wrote

963
00:45:57,799 --> 00:45:56,039

a paper in 2008 about the giant outburst

964
00:46:00,620 --> 00:45:57,809
of our 127 which as I said was

965
00:46:02,720 --> 00:46:00,630
discovered 1980 we studied it you know

966
00:46:08,829 --> 00:46:02,730
for almost 30 years and and then it came

967
00:46:11,089 --> 00:46:08,839
down down down down down down down down

968
00:46:13,910 --> 00:46:11,099
these are points from our previous paper

969
00:46:16,579 --> 00:46:13,920
published in 2008 and so toilet paper

970
00:46:19,099 --> 00:46:16,589
was the end of the three decade outburst

971
00:46:21,740 --> 00:46:19,109
of our 127 before the paper even appear

972
00:46:23,540 --> 00:46:21,750
in press I went back up again

973
00:46:25,190 --> 00:46:23,550
and that's what they do we don't

974
00:46:27,650 --> 00:46:25,200
understand them we don't understand why

975
00:46:30,320 --> 00:46:27,660
they do this and now as opposed to this

976
00:46:31,760 --> 00:46:30,330
sort of 30 year outburst with

977
00:46:32,780 --> 00:46:31,770
fluctuations and everything which I'm

978
00:46:37,210 --> 00:46:32,790
not showing you because I can't show you

979
00:46:40,490 --> 00:46:37,220
everything I have now it's had like four

980
00:46:42,830 --> 00:46:40,500
these undulations with timescales of two

981
00:46:45,170 --> 00:46:42,840
or three years why is it doing that what

982
00:46:47,450 --> 00:46:45,180
does it mean it is this reverberation a

983
00:46:49,280 --> 00:46:47,460
reaction to what happened before or is

984
00:46:51,830 --> 00:46:49,290
this kind of going to become a supernova

985
00:46:53,570 --> 00:46:51,840
and give us the delight that we would

986
00:46:58,339 --> 00:46:53,580
hope it's falling apart completely and

987
00:47:00,859 --> 00:46:58,349
will explode so that's what it's doing

988
00:47:03,800 --> 00:47:00,869

and unfortunately I can't explain to you

989
00:47:06,140 --> 00:47:03,810
why or how but there are obviously some

990
00:47:07,730 --> 00:47:06,150
instabilities inside the star related to

991
00:47:11,690 --> 00:47:07,740
the ending of the nuclear reactions and

992
00:47:13,970 --> 00:47:11,700
these LBV excursions and that's what

993
00:47:17,030 --> 00:47:13,980
it's doing now these marks down below

994
00:47:18,560 --> 00:47:17,040
our epics at which we have spectrum both

995
00:47:20,330 --> 00:47:18,570
high resolution and low resolution

996
00:47:23,210 --> 00:47:20,340
spectra and that's what I'll show you

997
00:47:24,710 --> 00:47:23,220
next and try to explain a little so the

998
00:47:27,320 --> 00:47:24,720
upper ones are high resolution spectra

999
00:47:31,430 --> 00:47:27,330
and they're low resolution so first I

1000
00:47:33,710 --> 00:47:31,440
have here a montage of these are V

1001
00:47:36,800 --> 00:47:33,720
magnitudes here so the magnitude is

1002
00:47:38,599 --> 00:47:36,810
Amino as a factor of 2.55 magnitudes is

1003
00:47:40,870 --> 00:47:38,609
a factor of 100 and brightness so so

1004
00:47:43,130 --> 00:47:40,880
this thing arranged over two magnitudes

1005
00:47:44,870 --> 00:47:43,140
during this period although it was

1006
00:47:47,359 --> 00:47:44,880
brighter than that it was like the

1007
00:47:53,839 --> 00:47:47,369
magnitude up at the top of the 1990 a

1008
00:47:57,260 --> 00:47:53,849
maximum well here is a sequence of the

1009
00:48:01,160 --> 00:47:57,270
spectra which Franca's kind of made

1010
00:48:02,480 --> 00:48:01,170
brighter so we can see the label is a

1011
00:48:03,920 --> 00:48:02,490
little better and I want to spend a

1012
00:48:06,790 --> 00:48:03,930
little time explaining them because I'm

1013
00:48:08,839 --> 00:48:06,800

sure most of you are not familiar with

1014
00:48:11,240 --> 00:48:08,849
astronomical spectra maybe not any

1015
00:48:13,400 --> 00:48:11,250
spectra and and we have a certain

1016
00:48:14,870 --> 00:48:13,410
notation so the first thing you see is

1017
00:48:17,270 --> 00:48:14,880
all these lines right

1018
00:48:19,339 --> 00:48:17,280
most of them going upwards those are

1019
00:48:21,079 --> 00:48:19,349
called emission lines actually it was

1020
00:48:23,870 --> 00:48:21,089
useful we had an introduction here about

1021
00:48:25,060 --> 00:48:23,880
a planet which cooler material produces

1022
00:48:26,920 --> 00:48:25,070
absorption and

1023
00:48:29,590 --> 00:48:26,930
produces a mission same things going on

1024
00:48:30,820 --> 00:48:29,600
here and so there are a few absorptions

1025
00:48:32,350 --> 00:48:30,830
you can say we'll see in some more

1026
00:48:36,340 --> 00:48:32,360
speculator which are dominated by

1027
00:48:38,920 --> 00:48:36,350
absorption but these are each one of

1028
00:48:43,630 --> 00:48:38,930
those lines is a transition of electrons

1029
00:48:47,620 --> 00:48:43,640
in an atom now most of you probably know

1030
00:48:50,320 --> 00:48:47,630
that some matter is made up of atoms in

1031
00:48:52,330 --> 00:48:50,330
developments and they have nuclei with

1032
00:48:53,590 --> 00:48:52,340
protons and neutrons and protons a

1033
00:48:54,910 --> 00:48:53,600
positive charge and then the neutral

1034
00:48:57,460 --> 00:48:54,920
state they have an equal number of

1035
00:48:59,320 --> 00:48:57,470
electrons to protons with negative

1036
00:49:03,130 --> 00:48:59,330
charges surrounding the nucleus so

1037
00:49:04,300 --> 00:49:03,140
they're electrically neutral electrons

1038
00:49:07,420 --> 00:49:04,310

are negative and the protons are

1039
00:49:08,890 --> 00:49:07,430
positive but a very interesting

1040
00:49:11,650 --> 00:49:08,900
important thing is if you increase the

1041
00:49:15,870 --> 00:49:11,660
temperature or decrease the pressure of

1042
00:49:18,820 --> 00:49:15,880
the gas containing this material these

1043
00:49:26,280 --> 00:49:18,830
atoms can be ionized and lose an

1044
00:49:28,840 --> 00:49:26,290
electron or two electrons or more and

1045
00:49:31,920 --> 00:49:28,850
when that happens then we call that and

1046
00:49:34,030 --> 00:49:31,930
I had known not an atom anymore and

1047
00:49:35,530 --> 00:49:34,040
furthermore its spectrum is completely

1048
00:49:38,500 --> 00:49:35,540
different all the lines which it

1049
00:49:40,750 --> 00:49:38,510
produced as an EM are gone and whole new

1050
00:49:42,700 --> 00:49:40,760
set of lines is produced by this ion

1051
00:49:45,100 --> 00:49:42,710
because the electronic states are

1052
00:49:49,210 --> 00:49:45,110
changed by the fact that there's one

1053
00:49:51,220 --> 00:49:49,220
fewer electron there and so if you get

1054
00:49:52,690 --> 00:49:51,230
transitions these electrons can be

1055
00:49:55,270 --> 00:49:52,700
different states and then they have

1056
00:49:56,710 --> 00:49:55,280
their sort of lowest States but then

1057
00:50:03,160 --> 00:49:56,720
they can get excited up to higher ones

1058
00:50:06,220 --> 00:50:03,170
and if an atom or ion absorbs a full

1059
00:50:10,030 --> 00:50:06,230
time electron can move up to a higher

1060
00:50:12,850 --> 00:50:10,040
state but then it can move down and emit

1061
00:50:16,080 --> 00:50:12,860
a photon and so electrons moving down

1062
00:50:19,240 --> 00:50:16,090
create emission lines and electrons

1063
00:50:22,420 --> 00:50:19,250

being absorbing photons produce

1064
00:50:25,000 --> 00:50:22,430
absorption so we have a continuum here

1065
00:50:28,150 --> 00:50:25,010
for each spectrum these I should say are

1066
00:50:31,150 --> 00:50:28,160
the specter of the same star believe it

1067
00:50:35,460 --> 00:50:31,160
or not taken at those dates which you

1068
00:50:47,380 --> 00:50:42,599
2008 let's take 2008 or say 2006 2008 to

1069
00:50:50,410 --> 00:50:47,390
2016 and all these huge variations that

1070
00:50:57,099 --> 00:50:50,420
you see occured during those eight years

1071
00:51:01,180 --> 00:50:57,109
and so here at the bottom the star was

1072
00:51:03,520 --> 00:51:01,190
in a hot state and so here you see these

1073
00:51:06,190 --> 00:51:03,530
notations which are combinations of

1074
00:51:09,900 --> 00:51:06,200
letters which are the chemical element

1075
00:51:12,880 --> 00:51:09,910
Fe is iron si is silicon HG is helium

1076
00:51:14,500 --> 00:51:12,890
and is nitrogen followed by a Roman

1077
00:51:17,200 --> 00:51:14,510
numeral and the Roman numeral

1078
00:51:19,930 --> 00:51:17,210
astronomers use to denote the ionic

1079
00:51:25,690 --> 00:51:19,940
state how many electrons has it lost so

1080
00:51:27,430 --> 00:51:25,700
if it would be Roman number one you

1081
00:51:28,870 --> 00:51:27,440
don't see many ones well you see some

1082
00:51:31,870 --> 00:51:28,880
helium one okay this is neutral helium

1083
00:51:35,020 --> 00:51:31,880
but this is ionized nitrogen this is a

1084
00:51:38,109 --> 00:51:35,030
doubly ionized iron doubly ionized

1085
00:51:39,490 --> 00:51:38,119
silicon and so these are identification

1086
00:51:41,530 --> 00:51:39,500
of these features in the spectra in fact

1087
00:51:42,760 --> 00:51:41,540
- here you see this this is mainly an

1088
00:51:44,620 --> 00:51:42,770

absorption although it has a bit of

1089
00:51:46,990 --> 00:51:44,630
mission on the red edges silicon

1090
00:51:50,050 --> 00:51:47,000
absorption triplet then you see this

1091
00:51:54,670 --> 00:51:50,060
nice multiplet here of nitrogen emission

1092
00:51:57,460 --> 00:51:54,680
lines and so this tells you right away

1093
00:51:59,380 --> 00:51:57,470
by studying the lines and especially the

1094
00:52:01,570 --> 00:51:59,390
ratios of lines from successive ions

1095
00:52:04,270 --> 00:52:01,580
what the temperature and the pressure of

1096
00:52:06,760 --> 00:52:04,280
the gas of this atmosphere or envelope

1097
00:52:08,740 --> 00:52:06,770
producing them is and so and you learned

1098
00:52:10,480 --> 00:52:08,750
the chemical composition you know there

1099
00:52:13,300 --> 00:52:10,490
are all sorts of details about the

1100
00:52:16,060 --> 00:52:13,310
physics of the atmosphere or the plasma

1101
00:52:17,349 --> 00:52:16,070
that these lines are in and as an added

1102
00:52:19,300 --> 00:52:17,359
bonus you get the radial velocity

1103
00:52:21,849 --> 00:52:19,310
because the positions of the lines which

1104
00:52:23,680 --> 00:52:21,859
are in principle fixed by the structure

1105
00:52:25,030 --> 00:52:23,690
of the atom but if there's a motion

1106
00:52:27,370 --> 00:52:25,040
along the line of sight between the

1107
00:52:29,500 --> 00:52:27,380
source and you then they move in

1108
00:52:31,810 --> 00:52:29,510
wavelength and you can measure that - so

1109
00:52:33,579 --> 00:52:31,820
it's not amazing we can get all of that

1110
00:52:35,770 --> 00:52:33,589
information and you know these these

1111
00:52:38,349 --> 00:52:35,780
stars are completely unresolved their

1112
00:52:40,599 --> 00:52:38,359
points I showed you that the the ejected

1113
00:52:42,310 --> 00:52:40,609

nebula of our 127 is resolved and we can

1114
00:52:44,210 --> 00:52:42,320
stay some spatial structure and happen

1115
00:52:47,569 --> 00:52:44,220
although this information about

1116
00:52:49,550 --> 00:52:47,579
the detailed physical details of the

1117
00:52:51,800 --> 00:52:49,560
star itself come from the spectrum

1118
00:52:53,870 --> 00:52:51,810
because they're so far away that they're

1119
00:52:55,300 --> 00:52:53,880
they're just mathematical points you

1120
00:53:01,280 --> 00:52:55,310
can't get any structural information

1121
00:53:03,230 --> 00:53:01,290
from images so then I think you

1122
00:53:05,569 --> 00:53:03,240
understand the basics I hope you do any

1123
00:53:07,880 --> 00:53:05,579
questions or doubts about what I just

1124
00:53:11,150 --> 00:53:07,890
tried there briefly explain this this is

1125
00:53:14,690 --> 00:53:11,160
you know semester course in 15 minutes

1126
00:53:19,130 --> 00:53:14,700
but I think you can capture the main

1127
00:53:20,900 --> 00:53:19,140
points and so see how it changes these

1128
00:53:23,510 --> 00:53:20,910
nitrogen lines here which correspond to

1129
00:53:26,900 --> 00:53:23,520
maybe a temperature of twenty thirty

1130
00:53:28,849 --> 00:53:26,910
thousand degrees weaker disappear gone

1131
00:53:29,990 --> 00:53:28,859
no longer there now I hear all these

1132
00:53:33,829 --> 00:53:30,000
other lines over here these are

1133
00:53:36,140 --> 00:53:33,839
magnesium two iron two lines cooler from

1134
00:53:38,630 --> 00:53:36,150
a cooler atmosphere so this star is

1135
00:53:41,930 --> 00:53:38,640
cooled I mean the it's expanded and it's

1136
00:53:47,180 --> 00:53:41,940
cooled and the visual magnitude has

1137
00:53:49,280 --> 00:53:47,190
gotten brighter and and then now by the

1138
00:53:52,069 --> 00:53:49,290

sequence it's coming back here there are

1139
00:53:54,589 --> 00:53:52,079
the nitrogen two lines again showing up

1140
00:53:58,550 --> 00:53:54,599
so over these eight years we observe

1141
00:54:00,710 --> 00:53:58,560
this star or this it'll be an outburst

1142
00:54:04,329 --> 00:54:00,720
to go from a hotter state through a

1143
00:54:07,309 --> 00:54:04,339
cooler one and then back to a hotter one

1144
00:54:09,589 --> 00:54:07,319
so that's what we're doing here I can't

1145
00:54:11,809 --> 00:54:09,599
tell you why but first you have to know

1146
00:54:13,250 --> 00:54:11,819
that it does this right if you didn't

1147
00:54:16,430 --> 00:54:13,260
even know this you're never gonna figure

1148
00:54:17,930 --> 00:54:16,440
out why sometimes you have an argument

1149
00:54:19,910 --> 00:54:17,940
irritations who don't like all these

1150
00:54:21,200 --> 00:54:19,920
observational details but they like to

1151
00:54:23,329 --> 00:54:21,210
explain things that's true the only way

1152
00:54:24,680 --> 00:54:23,339
you can explain things is by physics but

1153
00:54:29,210 --> 00:54:24,690
you can't explain something you don't

1154
00:54:37,120 --> 00:54:29,220
know first you have to discover what

1155
00:54:39,410 --> 00:54:37,130
happens usually okay well onward now

1156
00:54:40,430 --> 00:54:39,420
here I'm not going to spend a lot of

1157
00:54:42,320 --> 00:54:40,440
time on these because it's too much and

1158
00:54:44,920 --> 00:54:42,330
there's in time but

1159
00:54:46,849 --> 00:54:44,930
these are some panels from

1160
00:54:48,500 --> 00:54:46,859
high-resolution spectrograms they're

1161
00:54:50,900 --> 00:54:48,510
they're much more extended in fact

1162
00:54:53,089 --> 00:54:50,910
they're taken with the shells which use

1163
00:54:55,430 --> 00:54:53,099

multiple orders and and make a

1164
00:54:57,440 --> 00:54:55,440
two-dimensional format because otherwise

1165
00:55:00,500 --> 00:54:57,450
the thing would be a mile long if it

1166
00:55:05,510 --> 00:55:00,510
were a single spectrum like those little

1167
00:55:07,550 --> 00:55:05,520
resolution ones I showed you and so the

1168
00:55:10,060 --> 00:55:07,560
neat thing about these figures which my

1169
00:55:12,530 --> 00:55:10,070
colleague Roberta gummin made is it's

1170
00:55:14,839 --> 00:55:12,540
what you have along the left edge of

1171
00:55:18,349 --> 00:55:14,849
each of them is the light curve plotted

1172
00:55:20,810 --> 00:55:18,359
vertically okay so left is brighter and

1173
00:55:23,300 --> 00:55:20,820
then the right is cooler and then you

1174
00:55:26,170 --> 00:55:23,310
can look at the spectrum and see how it

1175
00:55:29,030 --> 00:55:26,180
changes as the temperature changes and

1176
00:55:30,950 --> 00:55:29,040
so here are these nitrogen lines that I

1177
00:55:32,570 --> 00:55:30,960
was showing you and you see a lot more

1178
00:55:34,730 --> 00:55:32,580
detail they have what we call a

1179
00:55:37,790 --> 00:55:34,740
composite P Sigma profile that's

1180
00:55:39,260 --> 00:55:37,800
combines redshifted emission and the

1181
00:55:41,540 --> 00:55:39,270
blue-shifted absorption and that's a

1182
00:55:46,520 --> 00:55:41,550
signature and expanding atmosphere by

1183
00:55:49,609 --> 00:55:46,530
the way or wind and you know they are

1184
00:55:51,800 --> 00:55:49,619
you know when the thing was faint 2008

1185
00:56:01,940 --> 00:55:51,810
now it starts to get brighter they're

1186
00:56:05,710 --> 00:56:01,950
gone as I told you it's helium one is

1187
00:56:10,810 --> 00:56:05,720
even more is more sensitive you see it's

1188
00:56:14,870 --> 00:56:10,820

its strongest when when the star is

1189
00:56:18,760 --> 00:56:14,880
hottest and faintest and goes away and

1190
00:56:22,310 --> 00:56:18,770
comes back it's very strong helium

1191
00:56:25,000 --> 00:56:22,320
neutral helium mine here that does that

1192
00:56:29,470 --> 00:56:25,010
over this sequence

1193
00:56:31,210 --> 00:56:29,480
here you see sodium one but those are

1194
00:56:33,130 --> 00:56:31,220
not in the star those are interstellar

1195
00:56:35,620 --> 00:56:33,140
lines very narrow very sharp lines a

1196
00:56:38,349 --> 00:56:35,630
very low ionization in gas and space

1197
00:56:44,050 --> 00:56:38,359
between the star and us interstellar

1198
00:56:46,720 --> 00:56:44,060
lines okay

1199
00:56:48,700 --> 00:56:46,730
that's the are 127 story then I have

1200
00:56:52,870 --> 00:56:48,710
let's move on to the second object which

1201
00:56:54,370 --> 00:56:52,880
is you know they have strong

1202
00:56:56,109 --> 00:56:54,380
similarities and that's their the the

1203
00:56:58,300 --> 00:56:56,119
bottom line of this talk is a strong

1204
00:56:59,770 --> 00:56:58,310
similarities between the behaviors of

1205
00:57:01,660 --> 00:56:59,780
these objects at different epochs and

1206
00:57:04,599 --> 00:57:01,670
among different objects at comparable

1207
00:57:08,080 --> 00:57:04,609
epochs but then you look in detail and

1208
00:57:11,680 --> 00:57:08,090
they all do different things and look at

1209
00:57:17,770 --> 00:57:11,690
the dates along the top of this plot

1210
00:57:19,180 --> 00:57:17,780
does that amaze you so this is another

1211
00:57:22,830 --> 00:57:19,190
thing we discovered in the course of

1212
00:57:25,109 --> 00:57:22,840
this work Harvard University is run

1213
00:57:27,130 --> 00:57:25,119

these stars of course in our genetic

1214
00:57:29,230 --> 00:57:27,140
chemistry you can't see the mirror you

1215
00:57:31,510 --> 00:57:29,240
have to go to South America or South

1216
00:57:33,450 --> 00:57:31,520
Africa and they had telescopes down

1217
00:57:35,950 --> 00:57:33,460
there from the late 19th century

1218
00:57:38,680 --> 00:57:35,960
monitoring stars and then taking spectra

1219
00:57:41,109 --> 00:57:38,690
and recently they digitized these data

1220
00:57:43,150 --> 00:57:41,119
and put them online and we looked and lo

1221
00:57:46,450 --> 00:57:43,160
and behold our 71 which was discovered

1222
00:57:47,650 --> 00:57:46,460
as an lbv in 1970 its gap year

1223
00:57:49,420 --> 00:57:47,660
well there's nothing where Harvard

1224
00:57:52,330 --> 00:57:49,430
stopped and no one was doing anything

1225
00:57:56,640 --> 00:57:52,340
until was discovered to be an lbv and at

1226
00:58:00,720 --> 00:57:56,650
these two huge Maxima right in 1914 and

1227
00:58:02,830 --> 00:58:00,730
1939 maybe you recognize those years so

1228
00:58:06,880 --> 00:58:02,840
let's hope that this even bigger one

1229
00:58:08,220 --> 00:58:06,890
here in 2016-2017 doesn't follow that

1230
00:58:10,450 --> 00:58:08,230
same trend

1231
00:58:13,300 --> 00:58:10,460
anyway this star has been having these

1232
00:58:15,430 --> 00:58:13,310
massive outbursts during the whole 20th

1233
00:58:20,020 --> 00:58:15,440
century we had no clue until we plotted

1234
00:58:24,960 --> 00:58:20,030
up these Harvard patrol data and and now

1235
00:58:28,810 --> 00:58:24,970
it's doing this had this outburst here

1236
00:58:30,730 --> 00:58:28,820
centered around 1970s and now right now

1237
00:58:32,680 --> 00:58:30,740
as I said earlier on it's the brightest

1238
00:58:34,089 --> 00:58:32,690

star in the

1239
00:58:38,770 --> 00:58:34,099
Magellanic Clouds brighter than 9th

1240
00:58:41,200 --> 00:58:38,780
magnitude and let's look at an expansion

1241
00:58:42,910 --> 00:58:41,210
of that right hand side there and the

1242
00:58:46,450 --> 00:58:42,920
next side so this just blows up the last

1243
00:58:48,309 --> 00:58:46,460
few years so you can see what it's doing

1244
00:58:51,400 --> 00:58:48,319
and so it was down here and then this

1245
00:58:53,349 --> 00:58:51,410
huge rise and now it's kind of flat just

1246
00:58:55,270 --> 00:58:53,359
sitting up there although you can see a

1247
00:58:57,220 --> 00:58:55,280
it's like kind of a periodic variation

1248
00:58:59,500 --> 00:58:57,230
there we're working on that that may be

1249
00:59:01,180 --> 00:58:59,510
some kind of pulsation or something that

1250
00:59:04,630 --> 00:59:01,190
will tell us more about what this star

1251
00:59:06,670 --> 00:59:04,640
is doing up at this maximum but it looks

1252
00:59:10,599 --> 00:59:06,680
like about 440 days as best you can tell

1253
00:59:12,010 --> 00:59:10,609
from that information and so now that's

1254
00:59:19,589 --> 00:59:12,020
where it is right now as far as last

1255
00:59:23,950 --> 00:59:19,599
check early 2017 and so we have spectra

1256
00:59:25,920 --> 00:59:23,960
at the epochs shown below and this is

1257
00:59:31,870 --> 00:59:25,930
the most boring slide I'll show you

1258
00:59:37,120 --> 00:59:31,880
which just almost constant absorption

1259
00:59:39,430 --> 00:59:37,130
line spectrum very boring but you see

1260
00:59:45,460 --> 00:59:39,440
the years there and look at look at the

1261
00:59:47,020 --> 00:59:45,470
previous one 2010 to 2016 and so this is

1262
00:59:51,849 --> 00:59:47,030
what its spectrum looks like as it's

1263
00:59:54,700 --> 00:59:51,859

just sitting up there on that its

1264
01:00:01,510 --> 00:59:54,710
maximum and these are absorption lines

1265
01:00:02,970 --> 01:00:01,520
cool cool atmosphere iron to most of

1266
01:00:08,020 --> 01:00:02,980
their into I have identified here

1267
01:00:09,400 --> 01:00:08,030
calcium to the hydrogen lines are even

1268
01:00:11,319 --> 01:00:09,410
in a sudden we still see hydrogen lines

1269
01:00:13,750 --> 01:00:11,329
because hydrogen is the most abundant

1270
01:00:16,359 --> 01:00:13,760
element and so it forms over a large

1271
01:00:19,540 --> 01:00:16,369
range of temperatures so I'm not too

1272
01:00:21,520 --> 01:00:19,550
much interesting to see there in terms

1273
01:00:23,260 --> 01:00:21,530
of variations but of course it's

1274
01:00:26,170 --> 01:00:23,270
important to know what it's doing and

1275
01:00:29,410 --> 01:00:26,180
now it relates to the light curve here

1276
01:00:32,470 --> 01:00:29,420
are some high-resolution observations of

1277
01:00:34,329 --> 01:00:32,480
this start which go back further than

1278
01:00:36,310 --> 01:00:34,339
our monitoring we get these for archives

1279
01:00:39,760 --> 01:00:36,320
like the European Southern Observatory

1280
01:00:41,520 --> 01:00:39,770
back when it was fainter and hotter and

1281
01:00:48,490 --> 01:00:41,530
so you can see how the spectrum changes

1282
01:00:51,100 --> 01:00:48,500
just like the are 127 from hütter

1283
01:00:53,380 --> 01:00:51,110
species and at the bottom up to these

1284
01:00:55,210 --> 01:00:53,390
cooler ones that if I here but we're in

1285
01:01:05,500 --> 01:00:55,220
this light and the specter you saw of

1286
01:01:07,960 --> 01:01:05,510
iron to here's a sort of curious detail

1287
01:01:09,430 --> 01:01:07,970
if you're curious about the

1288
01:01:12,100 --> 01:01:09,440

spectroscopic details remember I told

1289
01:01:13,720 --> 01:01:12,110
you these sodium one lines are very

1290
01:01:15,850 --> 01:01:13,730
narrow that's characteristic of

1291
01:01:18,010 --> 01:01:15,860
interstellar lines and they're too low

1292
01:01:19,780 --> 01:01:18,020
ionization for these hot stellar

1293
01:01:22,210 --> 01:01:19,790
atmospheres that form there but now look

1294
01:01:23,920 --> 01:01:22,220
what happens they get strong and broad

1295
01:01:26,020 --> 01:01:23,930
that's because they're now stellar

1296
01:01:28,300 --> 01:01:26,030
features the star has gotten so cool

1297
01:01:30,550 --> 01:01:28,310
that it can form sodium neutral sodium

1298
01:01:32,860 --> 01:01:30,560
lines in its own atmosphere and so the

1299
01:01:36,520 --> 01:01:32,870
interstellar lines you can see here are

1300
01:01:38,740 --> 01:01:36,530
obliterated by the by the star itself

1301
01:01:41,110 --> 01:01:38,750
actually it's even more interesting that

1302
01:01:42,910 --> 01:01:41,120
this is a doublet two lines so you see

1303
01:01:44,890 --> 01:01:42,920
two narrow ones and two broad ones okay

1304
01:01:47,500 --> 01:01:44,900
the two narrow ones are formed in our

1305
01:01:49,060 --> 01:01:47,510
galaxy in the halo of our galaxy the two

1306
01:01:50,770 --> 01:01:49,070
broad ones are formed in the Large

1307
01:01:52,660 --> 01:01:50,780
Magellanic Cloud which has a radius is

1308
01:01:54,820 --> 01:01:52,670
shifted relative to the galaxy so you

1309
01:01:58,540 --> 01:01:54,830
can see that the stellar sodium lines

1310
01:02:00,220 --> 01:01:58,550
are shifted red shifted to the velocity

1311
01:02:02,680 --> 01:02:00,230
that star has in the large menshikov

1312
01:02:04,630 --> 01:02:02,690
where is the galactic interstellar lines

1313
01:02:08,430 --> 01:02:04,640

of course unaffected by what this star

1314
01:02:16,020 --> 01:02:08,440
is doing 170,000 light-years away hmm

1315
01:02:20,970 --> 01:02:18,600
and finally I have one more star to show

1316
01:02:22,980 --> 01:02:20,980
you and very pleased with this one

1317
01:02:26,910 --> 01:02:22,990
because we have made that important

1318
01:02:29,460 --> 01:02:26,920
discovery which makes it a second our

1319
01:02:32,580 --> 01:02:29,470
127 that's its name up there from the

1320
01:02:35,910 --> 01:02:32,590
Henry Draper extension catalog to 695 a

1321
01:02:38,460 --> 01:02:35,920
- it's an LV was not really confirmed as

1322
01:02:40,770 --> 01:02:38,470
an LBV before work because there weren't

1323
01:02:42,420 --> 01:02:40,780
enough data I see big gaps there with no

1324
01:02:45,240 --> 01:02:42,430
one was interested in this star but

1325
01:02:47,370 --> 01:02:45,250
fortunately some people had observed it

1326
01:02:49,970 --> 01:02:47,380
and you see a twelfth magnitude very

1327
01:02:53,130 --> 01:02:49,980
faint and that is the magnitude that are

1328
01:02:55,050 --> 01:02:53,140
127 had I forgot to mention I studied

1329
01:02:57,990 --> 01:02:55,060
are 127 when I was on Sarah Doyle staff

1330
01:02:59,640 --> 01:02:58,000
in there in the 1970s and I discovered

1331
01:03:02,190 --> 01:02:59,650
it as a very peculiar commissioning

1332
01:03:04,620 --> 01:03:02,200
object with similar to a very small

1333
01:03:06,390 --> 01:03:04,630
number of stars are very rare and then I

1334
01:03:09,450 --> 01:03:06,400
discussed that group of stars and then

1335
01:03:11,490 --> 01:03:09,460
in 1985 it became a movie and then that

1336
01:03:12,930 --> 01:03:11,500
the first that we knew that this

1337
01:03:14,880 --> 01:03:12,940
particular class of peculiar mission

1338
01:03:19,080 --> 01:03:14,890

line stars is really quiescent state of

1339
01:03:21,000 --> 01:03:19,090
El Vivi's and again I contributed to

1340
01:03:24,060 --> 01:03:21,010
that so this star was being observed

1341
01:03:26,850 --> 01:03:24,070
here in the early 1990s and it was 12

1342
01:03:29,790 --> 01:03:26,860
magnitude and it had a spectrum like are

1343
01:03:34,410 --> 01:03:29,800
127 had before and then it did the same

1344
01:03:37,680 --> 01:03:34,420
thing 27 did and now it's bright yet

1345
01:03:40,080 --> 01:03:37,690
it's our 127 but maybe it will our 127

1346
01:03:42,300 --> 01:03:40,090
and a bunch of glitches before it got up

1347
01:03:44,460 --> 01:03:42,310
to the top and it has started going back

1348
01:03:51,210 --> 01:03:44,470
up again and so this is a light curve of

1349
01:03:53,700 --> 01:03:51,220
this star from 1990 to 2016 and of

1350
01:03:56,190 --> 01:03:53,710
course we have the spectrum and this is

1351
01:03:57,870 --> 01:03:56,200
maybe my favorite spectroscopic this one

1352
01:04:04,260 --> 01:03:57,880
is interesting the previous one was

1353
01:04:08,550 --> 01:04:04,270
boring but you see here the first one

1354
01:04:11,550 --> 01:04:08,560
which is from 1994 taken by British

1355
01:04:13,140 --> 01:04:11,560
astronomer to British astronomers one of

1356
01:04:14,450 --> 01:04:13,150
whom is here then dismiss them that Paul

1357
01:04:17,910 --> 01:04:14,460
Crowther

1358
01:04:20,370 --> 01:04:17,920
and here you see not nitrogen - as you

1359
01:04:23,340 --> 01:04:20,380
do here remember we saw that and then

1360
01:04:25,250 --> 01:04:23,350
that's like 20,000 degrees but nitrogen

1361
01:04:28,130 --> 01:04:25,260
3 it's a little bit

1362
01:04:30,700 --> 01:04:28,140
bird here but this is doubly ionized

1363
01:04:37,780 --> 01:04:30,710

nitrogen these two store lines and

1364
01:04:45,950 --> 01:04:44,240
helium two so this means this star at

1365
01:04:49,730 --> 01:04:45,960
this epoch was much harder than it was

1366
01:04:51,859 --> 01:04:49,740
here and this is what I call a no AFP

1367
01:04:54,320 --> 01:04:51,869
size w-9 star and it is the discovery

1368
01:04:57,290 --> 01:04:54,330
that this star had that state right back

1369
01:05:01,820 --> 01:04:57,300
when it had the faint magnitude 12:19

1370
01:05:04,070 --> 01:05:01,830
remember and now it got cooler it got as

1371
01:05:05,599 --> 01:05:04,080
cool as are 127 was it being a sequence

1372
01:05:07,490 --> 01:05:05,609
I show you yeah look at this whole

1373
01:05:09,760 --> 01:05:07,500
forest here of iron - mine's a type

1374
01:05:12,290 --> 01:05:09,770
spectrum very very cool 10,000 degrees

1375
01:05:14,540 --> 01:05:12,300
so it's got 30,000 degrees twenty

1376
01:05:23,090 --> 01:05:14,550
thousand ten thousand and now it's

1377
01:05:24,440 --> 01:05:23,100
started back again it's not quite the

1378
01:05:26,450 --> 01:05:24,450
nitrogen nine-time showing up to well

1379
01:05:28,730 --> 01:05:26,460
yet that's on the way or at least it's

1380
01:05:30,560 --> 01:05:28,740
headed in that direction so we have

1381
01:05:31,820 --> 01:05:30,570
shown for the first time that this star

1382
01:05:33,650 --> 01:05:31,830
is another bonafide

1383
01:05:35,480 --> 01:05:33,660
lbv which has now been observed all away

1384
01:05:38,599 --> 01:05:35,490
from its minimum of state twelfth

1385
01:05:43,730 --> 01:05:38,609
magnitude and ana Ledo type spectrum to

1386
01:05:45,460 --> 01:05:43,740
a type spectrum near maximum and that's

1387
01:05:47,630 --> 01:05:45,470
one of the neatest things in this paper

1388
01:05:49,730 --> 01:05:47,640

because that was not previously known

1389
01:05:52,070 --> 01:05:49,740
here you see what we have in the light

1390
01:05:54,680 --> 01:05:52,080
curve and again you see the same effects

1391
01:05:57,859 --> 01:05:54,690
that unfortunate there was there was

1392
01:06:00,710 --> 01:05:57,869
almost no father no photometry here but

1393
01:06:03,109 --> 01:06:00,720
we showed that it was faint back before

1394
01:06:05,150 --> 01:06:03,119
this in the 1990s and now it's bright

1395
01:06:06,950 --> 01:06:05,160
and these are all iron - a type of

1396
01:06:09,500 --> 01:06:06,960
clients this is a forest of lines you

1397
01:06:11,570 --> 01:06:09,510
saw before in the little resolution and

1398
01:06:14,240 --> 01:06:11,580
I started to get hotter again and and

1399
01:06:18,170 --> 01:06:14,250
these lines of weaken and some higher

1400
01:06:21,140 --> 01:06:18,180
ionization lines are appearing same

1401
01:06:22,670 --> 01:06:21,150
thing same story same lines here here

1402
01:06:25,310 --> 01:06:22,680
you see the nitrogen two lines in this

1403
01:06:27,440 --> 01:06:25,320
wavelength range very clearly they're

1404
01:06:29,550 --> 01:06:27,450
disappear completely replaced by iron

1405
01:06:31,650 --> 01:06:29,560
two lines and

1406
01:06:33,350 --> 01:06:31,660
coming back to you see the helium here

1407
01:06:36,390 --> 01:06:33,360
you see the helium how it was strong

1408
01:06:41,580 --> 01:06:36,400
disappeared this is an iron mine and

1409
01:06:43,670 --> 01:06:41,590
coming back now as it gets hotter over

1410
01:06:48,150 --> 01:06:43,680
there

1411
01:06:50,820 --> 01:06:48,160
so that's what these stars do someday

1412
01:06:54,510 --> 01:06:50,830
we'll understand why and this is the

1413
01:06:56,900 --> 01:06:54,520

final I find all plot here putting all

1414
01:06:59,160 --> 01:06:56,910
of these stars and a couple other ones

1415
01:07:00,240 --> 01:06:59,170
two of which are in the paper and I'm

1416
01:07:03,470 --> 01:07:00,250
one of which isn't even in the paper

1417
01:07:08,220 --> 01:07:03,480
restaurantes on the same diagram of

1418
01:07:10,410 --> 01:07:08,230
brightness versus spectral type Oba f.g

1419
01:07:12,870 --> 01:07:10,420
the Sun is a G star the hottest stars

1420
01:07:15,210 --> 01:07:12,880
are Oh stars and DA effort intermediates

1421
01:07:17,430 --> 01:07:15,220
and so the point is this is to show that

1422
01:07:19,470 --> 01:07:17,440
you've got all these stars in this

1423
01:07:22,740 --> 01:07:19,480
diagram and they all do the same thing

1424
01:07:25,200 --> 01:07:22,750
the there's this correlation between

1425
01:07:27,930 --> 01:07:25,210
their brightness in these outbursts and

1426
01:07:32,310 --> 01:07:27,940
their temperatures or spectral types and

1427
01:07:33,810 --> 01:07:32,320
that is a very important clue to what is

1428
01:07:35,700 --> 01:07:33,820
happening the physical mechanism and we

1429
01:07:38,340 --> 01:07:35,710
don't understand and this is what has to

1430
01:07:41,520 --> 01:07:38,350
be explained how and why did I do this

1431
01:07:47,400 --> 01:07:41,530
so I actually my what my co-authors made

1432
01:07:50,840 --> 01:07:47,410
this file sign and he he kindly quoted

1433
01:07:55,260 --> 01:07:50,850
some of my prose in this slide which is

1434
01:07:59,820 --> 01:07:55,270
really the main point in conclusion of

1435
01:08:12,470 --> 01:07:59,830
this state thank you

1436
01:08:25,440 --> 01:08:19,950
okay so questions do we have any your

1437
01:08:30,210 --> 01:08:25,450
last chart shows that as they get cooler

1438
01:08:32,729 --> 01:08:30,220

they get brighter then is anything is

1439
01:08:35,690 --> 01:08:32,739
that because they're getting larger yes

1440
01:08:40,380 --> 01:08:35,700
they get brighter and visual magnitude

1441
01:08:43,200 --> 01:08:40,390
but not in there and the very first

1442
01:08:44,809 --> 01:08:43,210
slide you go back to the first one on

1443
01:08:46,979 --> 01:08:44,819
this or you just have to flow back oh

1444
01:08:49,140 --> 01:08:46,989
that's nice didn't want that that's

1445
01:08:52,140 --> 01:08:49,150
crucially they get a brighter visual

1446
01:08:54,210 --> 01:08:52,150
life because the ultraviolet energy is

1447
01:08:56,729 --> 01:08:54,220
being reprocessed by this expanding and

1448
01:08:59,910 --> 01:08:56,739
cooler envelope to lower temperatures

1449
01:09:02,610 --> 01:08:59,920
but what the chart I showed the graph of

1450
01:09:05,610 --> 01:09:02,620
the very first slide shows is that there

1451
01:09:08,280 --> 01:09:05,620
Bholu entering luminosities which is the

1452
01:09:10,260 --> 01:09:08,290
sum of all wavelengths all energy being

1453
01:09:10,910 --> 01:09:10,270
emitted by the nuclear reaction doesn't

1454
01:09:13,829 --> 01:09:10,920
change

1455
01:09:19,650 --> 01:09:13,839
see those excursion lines are flattest

1456
01:09:21,599 --> 01:09:19,660
right this is about the internet

1457
01:09:24,450 --> 01:09:21,609
generation that is changing it's not the

1458
01:09:26,220 --> 01:09:24,460
evolution if it's some structural

1459
01:09:28,950 --> 01:09:26,230
instability inside the star which is

1460
01:09:31,499 --> 01:09:28,960
causing these expansions and whatever

1461
01:09:33,030 --> 01:09:31,509
adjustments inside the star and the

1462
01:09:35,900 --> 01:09:33,040
interview generation just goes on the

1463
01:09:39,360 --> 01:09:35,910

same as it was but the visual magnitude

1464
01:09:41,160 --> 01:09:39,370
which is becomes enhanced at these

1465
01:09:43,590 --> 01:09:41,170
cooler bases and that's what I've been

1466
01:09:45,750 --> 01:09:43,600
showing you in the Lakers and so

1467
01:09:47,370 --> 01:09:45,760
very important point thank you right

1468
01:09:49,920 --> 01:09:47,380
yeah we actually had a little bit of

1469
01:09:54,450 --> 01:09:49,930
that discussion online just clarifying

1470
01:09:56,040 --> 01:09:54,460
that as they get brighter they're

1471
01:09:58,050 --> 01:09:56,050
actually getting cooler and it's dudes

1472
01:10:00,720 --> 01:09:58,060
well like the expansion and contraction

1473
01:10:02,460 --> 01:10:00,730
of the star yeah and a reprocessing of

1474
01:10:05,370 --> 01:10:02,470
the hotter radiation to lower

1475
01:10:06,720 --> 01:10:05,380
temperatures but the total amount of

1476
01:10:09,270 --> 01:10:06,730
energy emitted by the star is not

1477
01:10:10,410 --> 01:10:09,280
changing right one person wanted to know

1478
01:10:13,170 --> 01:10:10,420
if it had anything to do with solar

1479
01:10:14,790 --> 01:10:13,180
flares I I said I don't think there's

1480
01:10:16,530 --> 01:10:14,800
any national flares

1481
01:10:20,010 --> 01:10:16,540
well since we don't know if this is due

1482
01:10:21,810 --> 01:10:20,020
to as they say no but it sounds a cool

1483
01:10:30,060 --> 01:10:21,820
star the physics of cool stars it's very

1484
01:10:32,430 --> 01:10:30,070
different so many stars have some kind

1485
01:10:38,700 --> 01:10:32,440
of flares or something certainly some of

1486
01:10:40,800 --> 01:10:38,710
these ejections are not preferred axes

1487
01:10:43,380 --> 01:10:40,810
and directions so there's lots of the

1488
01:10:44,940 --> 01:10:43,390

cure physics but most likely it's no

1489
01:10:46,470 --> 01:10:44,950
that's out of question magnetic fields

1490
01:10:49,290 --> 01:10:46,480
are involved in some way good things all

1491
01:10:52,920 --> 01:10:49,300
that well it's different physics from

1492
01:10:54,810 --> 01:10:52,930
what you're having cool stars okay all

1493
01:10:56,700 --> 01:10:54,820
right pick up additional material either

1494
01:10:57,630 --> 01:10:56,710
from a neighboring star or from

1495
01:10:59,340 --> 01:10:57,640
interstellar space

1496
01:11:02,190 --> 01:10:59,350
all right so let me repeat that for the

1497
01:11:04,200 --> 01:11:02,200
online ions can stars pick up material

1498
01:11:06,900 --> 01:11:04,210
from neighboring stars we're in a

1499
01:11:09,030 --> 01:11:06,910
stellar space oh very very neighboring

1500
01:11:11,400 --> 01:11:09,040
stars namely binary companions as we

1501
01:11:15,330 --> 01:11:11,410
mentioned over here when you have two

1502
01:11:17,700 --> 01:11:15,340
stars a very close together so he starts

1503
01:11:20,160 --> 01:11:17,710
at two massive stars closer than the Sun

1504
01:11:25,020 --> 01:11:20,170
is to the earth to each other and when

1505
01:11:26,670 --> 01:11:25,030
they start to evolve and expand they was

1506
01:11:28,290 --> 01:11:26,680
expanding made up huge amounts of

1507
01:11:29,850 --> 01:11:28,300
material at the other star and actually

1508
01:11:31,680 --> 01:11:29,860
invert the mass ratio such that the

1509
01:11:33,300 --> 01:11:31,690
original star which is lower mass

1510
01:11:38,020 --> 01:11:33,310
therefore had evolved yet becomes the

1511
01:12:23,480 --> 01:12:20,300
and this variable star has been studied

1512
01:12:25,280 --> 01:12:23,490
for decades and decades as any of that

1513
01:12:28,250 --> 01:12:25,290

study produced an understanding of the

1514
01:12:30,830 --> 01:12:28,260
mechanism of the variation and is that

1515
01:12:32,720 --> 01:12:30,840
similar to or descent out in the

1516
01:12:35,180 --> 01:12:32,730
application to what's happening in the

1517
01:12:37,330 --> 01:12:35,190
blue variables okay so the question was

1518
01:12:40,370 --> 01:12:37,340
variable starts um it's time for decades

1519
01:12:43,730 --> 01:12:40,380
does that indicate what the mechanism

1520
01:12:44,870 --> 01:12:43,740
that's underneath this variability well

1521
01:12:46,400 --> 01:12:44,880
of course there may be different kinds

1522
01:12:50,330 --> 01:12:46,410
of variable stars as you probably know

1523
01:12:52,640 --> 01:12:50,340
and so they have different causes one of

1524
01:12:54,110 --> 01:12:52,650
the neatest ones it's eclipsing - and

1525
01:12:57,410 --> 01:12:54,120
these two stars going around each other

1526
01:13:06,200 --> 01:12:57,420
if they're all I'm just right with each

1527
01:13:08,750 --> 01:13:06,210
other binary stars are some of those

1528
01:13:11,420 --> 01:13:08,760
famous variable stars are pulsating

1529
01:13:14,150 --> 01:13:11,430
variable stars and there's instability

1530
01:13:17,780 --> 01:13:14,160
strips in the HR diagram which are not

1531
01:13:19,670 --> 01:13:17,790
shown here most of the effects lower

1532
01:13:21,440 --> 01:13:19,680
mass stars at cooler temperatures than

1533
01:13:24,680 --> 01:13:21,450
shown here and when they try to evolve

1534
01:13:28,910 --> 01:13:24,690
through these strips they become

1535
01:13:32,620 --> 01:13:28,920
unstable - pulsations and so they start

1536
01:13:36,860 --> 01:13:32,630
expanding and retracting periodically

1537
01:13:39,620 --> 01:13:36,870
timescales of days few days

1538
01:13:41,930 --> 01:13:39,630

and the status of those will set bids

1539
01:13:43,760 --> 01:13:41,940
and they turned out to be extremely

1540
01:13:45,200 --> 01:13:43,770
useful because they were discovered

1541
01:13:47,590 --> 01:13:45,210
early on and it was discovered that

1542
01:13:51,020 --> 01:13:47,600
their period is related to their

1543
01:13:54,800 --> 01:13:51,030
luminosity and so you can measure the

1544
01:13:58,280 --> 01:13:54,810
period very easily and their parents and

1545
01:13:59,330 --> 01:13:58,290
then the absolute not see how far away

1546
01:14:01,100 --> 01:13:59,340
they were and this is one of the main

1547
01:14:05,150 --> 01:14:01,110
ways of determining distances to

1548
01:14:15,770 --> 01:14:05,160
external galaxies through the periodic

1549
01:14:19,820 --> 01:14:15,780
stations so that's pretty well

1550
01:14:21,590 --> 01:14:19,830
understood is not what's happening here

1551
01:14:25,990 --> 01:14:21,600
that's not to say there's an emulation I

1552
01:14:35,410 --> 01:14:29,300
somewhere is the outer layers of the

1553
01:14:39,650 --> 01:14:38,030
these are major the adjustments inside

1554
01:14:47,330 --> 01:14:39,660
the star and not in the nuclear

1555
01:14:48,680 --> 01:14:47,340
reactions but in mass motion and those

1556
01:14:59,210 --> 01:14:48,690
are the kinds of things people think of

1557
01:15:01,040 --> 01:14:59,220
as models and our models give you a

1558
01:15:04,730 --> 01:15:01,050
question down front

1559
01:15:07,250 --> 01:15:04,740
sort of simpler the orbital periods for

1560
01:15:09,710 --> 01:15:07,260
these binaries and tidal forces play

1561
01:15:11,780 --> 01:15:09,720
role in because of this sort of acid

1562
01:15:12,810 --> 01:15:11,790
this redistribution thanks the question

1563
01:15:15,150 --> 01:15:12,820

is can antenna

1564
01:15:19,950 --> 01:15:15,160
play as stronger all this massive

1565
01:15:22,580 --> 01:15:19,960
redistribution they can and and yes they

1566
01:15:24,660 --> 01:15:22,590
can even probably even trigger outbursts

1567
01:15:28,560 --> 01:15:24,670
especially in some peculiar kinds of

1568
01:15:31,050 --> 01:15:28,570
stars so sure but just like you know the

1569
01:15:33,690 --> 01:15:31,060
moon affects their associated to form

1570
01:15:35,040 --> 01:15:33,700
the tides the same thing happens these

1571
01:15:36,510 --> 01:15:35,050
close binary stars course the closer

1572
01:15:40,920 --> 01:15:36,520
they are the more massive a rather more

1573
01:15:42,150 --> 01:15:40,930
extreme the effects and and you could

1574
01:15:45,240 --> 01:15:42,160
study this

1575
01:15:47,430 --> 01:15:45,250
there are surpassing detailed field of

1576
01:15:49,320 --> 01:15:47,440
dynamics and about how they rotate and

1577
01:15:51,120 --> 01:15:49,330
they revolve and then they get locked

1578
01:15:53,910 --> 01:15:51,130
into synchronism as the boys by the way

1579
01:15:59,120 --> 01:15:53,920
it's the same case same side faces the

1580
01:16:04,920 --> 01:16:01,920
question this is so very eccentric

1581
01:16:06,990 --> 01:16:04,930
binaries and reasons there's some

1582
01:16:09,270 --> 01:16:07,000
binaries which are very eccentric that

1583
01:16:13,110 --> 01:16:09,280
is to say they're they're almost linear

1584
01:16:14,550 --> 01:16:13,120
anything that they have and speed stars

1585
01:16:17,040 --> 01:16:14,560
increases when they're close together

1586
01:16:19,350 --> 01:16:17,050
that decreases and then increases and

1587
01:16:22,560 --> 01:16:19,360
they would by each other and these

1588
01:16:24,810 --> 01:16:22,570

periosteum passages oh very good and

1589
01:16:27,300 --> 01:16:24,820
then there can be extreme effects which

1590
01:16:29,220 --> 01:16:27,310
and some of these are binaries involving

1591
01:16:32,460 --> 01:16:29,230
neutron stars you from black holes which

1592
01:16:35,070 --> 01:16:32,470
are extremely dense and very strong

1593
01:16:37,290 --> 01:16:35,080
gravitational fields and you can get

1594
01:16:38,460 --> 01:16:37,300
some kinds of explosions and outbursts

1595
01:16:42,750 --> 01:16:38,470
and things which are triggered by

1596
01:16:43,380 --> 01:16:42,760
probably by tides periastron passages in

1597
01:16:48,930 --> 01:16:43,390
eccentric

1598
01:16:51,060 --> 01:16:48,940
miners okay I question for you is it

1599
01:16:53,250 --> 01:16:51,070
occurring considered a luminous blue

1600
01:16:56,790 --> 01:16:53,260
variable yeah that's a good question and

1601
01:17:02,070 --> 01:16:56,800
yes I know that you'll find it included

1602
01:17:04,080 --> 01:17:02,080
in the entire think about any karate is

1603
01:17:05,910 --> 01:17:04,090
because our state is a bit in great

1604
01:17:08,190 --> 01:17:05,920
detail it happens to be fairly close by

1605
01:17:27,920 --> 01:17:08,200
and then the stars that's associated

1606
01:18:37,290 --> 01:18:33,840
and it's especially since these LEDs and

1607
01:18:40,230 --> 01:18:37,300
in a car have these bursts that happened

1608
01:18:42,480 --> 01:18:40,240
for years and decades and you have to

1609
01:18:46,380 --> 01:18:42,490
watch them much more than the you know

1610
01:18:48,960 --> 01:18:46,390
graduate students lifetime or even more

1611
01:18:51,660 --> 01:18:48,970
than astronomers lifetime it makes it a

1612
01:18:53,910 --> 01:18:51,670
white problem it does but that

1613
01:18:56,040 --> 01:18:53,920

stimulates me to add something very

1614
01:18:57,810 --> 01:18:56,050
fascinating here we have a stronger here

1615
01:19:00,720 --> 01:18:57,820
at German astronomers name is Armin rest

1616
01:19:03,120 --> 01:19:00,730
and he specializes in light echoes and

1617
01:19:06,090 --> 01:19:03,130
these are delayed arrival of light

1618
01:19:12,240 --> 01:19:06,100
outburst from supernovae he started

1619
01:19:19,470 --> 01:19:12,250
kurani by light scattered reflected from

1620
01:19:22,830 --> 01:19:19,480
dust clouds so he has gone on to the

1621
01:19:27,120 --> 01:19:22,840
curricula and he is discovered and

1622
01:19:32,190 --> 01:19:27,130
observed these knots first one through

1623
01:19:34,860 --> 01:19:32,200
the historical break I think we have the

1624
01:19:36,930 --> 01:19:34,870
spectrum of the elders you know there

1625
01:19:39,030 --> 01:19:36,940
were no spectrographs in 1837 when this

1626
01:19:41,370 --> 01:19:39,040
happened now with this technique we've

1627
01:19:44,190 --> 01:19:41,380
been able to go back and get the

1628
01:20:18,300 --> 01:19:44,200
spectrum Vedic Iranian outburst in 1837

1629
01:20:19,830 --> 01:20:18,310
before we had any spectrum now the

1630
01:20:25,140 --> 01:20:19,840
Europeans are building a 40 meter

1631
01:20:29,700 --> 01:20:25,150
telescope to somebody and kind of go

1632
01:20:37,140 --> 01:20:29,710
back from 200 AD before our baby

1633
01:20:42,190 --> 01:20:39,580
using the speed of light

1634
01:20:44,680 --> 01:20:42,200
look back in time even at something that

1635
01:20:48,340 --> 01:20:44,690
we know happened historically by looking

1636
01:20:50,590 --> 01:20:48,350
at the echoes from it so these variable

1637
01:20:52,360 --> 01:20:50,600
stars will hope will keep keeping

1638
01:20:53,950 --> 01:20:52,370

astronomers gainfully employed for quite

1639
01:20:57,130 --> 01:20:53,960
some time all right

1640
01:20:58,840 --> 01:20:57,140
next month will be our look at Cassini's

1641
01:20:59,530 --> 01:20:58,850
grand finale it's Saturn with bunny

1642
01:21:08,280 --> 01:20:59,540
monkey