

1
00:00:00,000 --> 00:00:06,028
I to study cosmology all right in

2
00:00:03,229 --> 00:00:07,830
December Christine Chen will be talking

3
00:00:06,028 --> 00:00:11,460
about debris disks and the evolution of

4
00:00:07,830 --> 00:00:14,460
planetary systems yet another one of the

5
00:00:11,460 --> 00:00:16,650
hot topics in astronomy talking about

6
00:00:14,460 --> 00:00:19,650
extrasolar planets and how planetary

7
00:00:16,649 --> 00:00:24,960
systems develop I mean I remember when I

8
00:00:19,649 --> 00:00:26,459
was a wee lad just an undergraduate we

9
00:00:24,960 --> 00:00:28,560
knew nothing about how planetary systems

10
00:00:26,460 --> 00:00:30,480
develop and the amount that we know now

11
00:00:28,559 --> 00:00:31,549
is just amazing it's one of the one of

12
00:00:30,480 --> 00:00:33,899
the great topics

13
00:00:31,550 --> 00:00:38,399
unfortunately in January we have our

14
00:00:33,899 --> 00:00:40,170
favors speaker TBA because it's hard to

15
00:00:38,399 --> 00:00:42,960
get somebody just after New Year's I

16
00:00:40,170 --> 00:00:45,300
wanted to ask Li asked a question folks

17
00:00:42,960 --> 00:00:48,210
would you prefer that we delayed this

18
00:00:45,299 --> 00:00:51,089
until January 10th instead of January

19
00:00:48,210 --> 00:00:51,929
3rd or would that or would that not make

20
00:00:51,090 --> 00:00:55,190
a difference

21
00:00:51,929 --> 00:00:57,600
anybody think it would be good to delay

22
00:00:55,189 --> 00:01:00,539
anybody okay with everybody would just

23
00:00:57,600 --> 00:01:03,929
think the third is better and who

24
00:01:00,539 --> 00:01:06,890
doesn't really care okay overwhelming

25
00:01:03,929 --> 00:01:10,549
don't care a little bit towards the

26
00:01:06,890 --> 00:01:12,989
towards the January 10th because the

27
00:01:10,549 --> 00:01:15,270
American Astronomical Society meets the

28
00:01:12,989 --> 00:01:16,798
first week of January and I often have

29

00:01:15,269 --> 00:01:19,500
trouble getting speakers because half

30
00:01:16,799 --> 00:01:22,950
the Institute is out at the conference

31
00:01:19,500 --> 00:01:25,650
so I might some I might consider

32
00:01:22,950 --> 00:01:27,359
delaying that all right oh the

33
00:01:25,650 --> 00:01:28,859
construction update hopefully you guys

34
00:01:27,359 --> 00:01:30,478
had to come a different way to get here

35
00:01:28,859 --> 00:01:32,879
hopefully obviously you made it

36
00:01:30,478 --> 00:01:34,438
hopefully there isn't another 50 people

37
00:01:32,879 --> 00:01:37,048
out there getting lost

38
00:01:34,438 --> 00:01:40,709
if so hopefully they will find their way

39
00:01:37,049 --> 00:01:44,220
in you have to come from the south

40
00:01:40,709 --> 00:01:47,188
because north of it is closed here is

41
00:01:44,219 --> 00:01:49,289
the map this blue part is the stuff

42
00:01:47,188 --> 00:01:51,478
that's done looks real nice especially

43
00:01:49,290 --> 00:01:53,670

this path along here is a really nice

44

00:01:51,478 --> 00:01:56,158

little path if you see it when you're

45

00:01:53,670 --> 00:01:58,978

during the daylight but this yellow

46

00:01:56,159 --> 00:02:01,680

section here and this red section up

47

00:01:58,978 --> 00:02:03,929

here those are now closed and will be

48

00:02:01,680 --> 00:02:05,820

through December ok so for the next

49

00:02:03,930 --> 00:02:08,550

several months you'll have to approach

50

00:02:05,819 --> 00:02:12,150

from the south it definitely has length

51

00:02:08,550 --> 00:02:13,469

into my commute our website with

52

00:02:12,150 --> 00:02:15,450

information

53

00:02:13,469 --> 00:02:17,189

is if you look if you just take your

54

00:02:15,449 --> 00:02:19,859

favorite search engine and look for

55

00:02:17,189 --> 00:02:22,800

Hubble public talks you'll find it we

56

00:02:19,860 --> 00:02:25,680

have links to our live webcasting both

57

00:02:22,800 --> 00:02:28,080

on YouTube and on the STScI webcasting

58
00:02:25,680 --> 00:02:30,030
site our archives of the past lectures

59
00:02:28,080 --> 00:02:32,280
again on YouTube and the STScI

60
00:02:30,030 --> 00:02:34,620
webcasting and a feature that has been

61
00:02:32,280 --> 00:02:37,229
used an awful lot because I get an email

62
00:02:34,620 --> 00:02:39,689
every time it is used people signing up

63
00:02:37,229 --> 00:02:42,289
for our announcements

64
00:02:39,689 --> 00:02:45,120
thank you all for signing up but it

65
00:02:42,289 --> 00:02:47,129
makes my job a lot easier in getting the

66
00:02:45,120 --> 00:02:49,200
information out to people not only

67
00:02:47,129 --> 00:02:51,810
around the Baltimore area but across the

68
00:02:49,199 --> 00:02:54,989
country we also of course have our list

69
00:02:51,810 --> 00:02:57,060
of upcoming lectures so visit our

70
00:02:54,990 --> 00:03:00,180
website to find that all that wonderful

71
00:02:57,060 --> 00:03:02,009
information announcements well I'll just

72
00:03:00,180 --> 00:03:04,530
use our website because there is mail

73
00:03:02,009 --> 00:03:07,349
list at STScI dat edu but it's much more

74
00:03:04,530 --> 00:03:09,180
difficult just use our website if you

75
00:03:07,349 --> 00:03:12,439
want to contact us you can send an email

76
00:03:09,180 --> 00:03:16,469
to public lecture at stsci edu ask

77
00:03:12,439 --> 00:03:19,169
comments or questions we are also on

78
00:03:16,469 --> 00:03:22,859
social media Facebook to Twitter

79
00:03:19,169 --> 00:03:24,958
accounts Google Pinterest I will note

80
00:03:22,860 --> 00:03:26,730
that my Hubble's universe unfiltered

81
00:03:24,959 --> 00:03:30,060
blog and Hubble site is getting updated

82
00:03:26,729 --> 00:03:31,979
more frequently we have it's the new

83
00:03:30,060 --> 00:03:33,629
fiscal year the funding for this fiscal

84
00:03:31,979 --> 00:03:36,780
year has enabled me to put more time

85
00:03:33,629 --> 00:03:39,509
into my blog I'm putting I put up three

86

00:03:36,780 --> 00:03:42,060
posts last month I also do Facebook

87
00:03:39,509 --> 00:03:45,120
Google and Twitter every now and then I

88
00:03:42,060 --> 00:03:48,989
don't promise to be daily at all hunt

89
00:03:45,120 --> 00:03:50,730
something like that Observatory I do not

90
00:03:48,989 --> 00:03:52,680
I didn't check my email late this

91
00:03:50,729 --> 00:03:57,238
afternoon the person from the

92
00:03:52,680 --> 00:03:59,640
observatory is obviously not here remind

93
00:03:57,239 --> 00:04:01,409
me to ask again at the end to see if

94
00:03:59,639 --> 00:04:05,488
they are here to take us up to the

95
00:04:01,409 --> 00:04:09,389
observatory tonight okay and now news

96
00:04:05,489 --> 00:04:15,390
from the universe for October 2016

97
00:04:09,389 --> 00:04:17,370
our first story lovely plumage on Europa

98
00:04:15,389 --> 00:04:21,149
how many of you recognize the phrase

99
00:04:17,370 --> 00:04:23,280
lovely plumage alright oh not that many

100
00:04:21,149 --> 00:04:26,519

oh oh this isn't a reference for this

101

00:04:23,279 --> 00:04:27,099

audience all right this is from the dead

102

00:04:26,519 --> 00:04:30,060

parrot

103

00:04:27,100 --> 00:04:32,620

sketch of Monty Python's Flying Circus

104

00:04:30,060 --> 00:04:35,410

where John Cleese's

105

00:04:32,620 --> 00:04:37,990

customer comes in to return a parrot

106

00:04:35,410 --> 00:04:40,630

that is dead and Michael Palin as the

107

00:04:37,990 --> 00:04:42,340

shop owner tries to refuse to

108

00:04:40,629 --> 00:04:45,250

acknowledge that the parrot is dead

109

00:04:42,339 --> 00:04:48,549

saying all the Norwegian blues lovely

110

00:04:45,250 --> 00:04:51,040

plumage and just talks about how it is

111

00:04:48,550 --> 00:04:54,579

you know you know it's just resting it's

112

00:04:51,040 --> 00:04:57,430

pining for the fjords and such this is

113

00:04:54,579 --> 00:05:00,159

an extremely famous sketch amongst Monty

114

00:04:57,430 --> 00:05:03,639

Python fans so much so that when Monty

115
00:05:00,160 --> 00:05:08,370
Python had a reunion in London it was

116
00:05:03,639 --> 00:05:13,629
celebrated with a 50-foot dead parrot

117
00:05:08,370 --> 00:05:15,069
the Tower Bridge so lovely plumage has

118
00:05:13,629 --> 00:05:19,209
very little to do with this story I just

119
00:05:15,069 --> 00:05:24,909
wanted to show this image but the plumes

120
00:05:19,209 --> 00:05:27,939
on Europa are these and they're not

121
00:05:24,910 --> 00:05:29,830
really quite so lovely to look at

122
00:05:27,939 --> 00:05:33,250
matter of fact you may not even see them

123
00:05:29,829 --> 00:05:36,250
unless I put in the arrows okay all

124
00:05:33,250 --> 00:05:38,709
right so this is a an image of Europa

125
00:05:36,250 --> 00:05:41,560
from the Galileo mission it's a a mosaic

126
00:05:38,709 --> 00:05:44,079
put together and these are the plumes

127
00:05:41,560 --> 00:05:47,439
down here in white the background is

128
00:05:44,079 --> 00:05:49,479
from the Hubble instrument okay oh and

129
00:05:47,439 --> 00:05:51,279
you're seeing this white stuff down here

130
00:05:49,480 --> 00:05:55,629
and it's kind of pixelated and stuff and

131
00:05:51,279 --> 00:05:59,319
I wouldn't call it lovely they're kind

132
00:05:55,629 --> 00:06:02,500
of ratty except there is a really lovely

133
00:05:59,319 --> 00:06:04,689
science story behind it so let me

134
00:06:02,500 --> 00:06:07,449
explain the science behind it and you'll

135
00:06:04,689 --> 00:06:10,300
see how beautiful they really can be so

136
00:06:07,449 --> 00:06:12,699
this is Jupiter's moon Europa it's the

137
00:06:10,300 --> 00:06:16,120
smallest of the four Galilean moons okay

138
00:06:12,699 --> 00:06:20,379
and we believe its interior structure

139
00:06:16,120 --> 00:06:20,740
has an iron core metallic core it has a

140
00:06:20,379 --> 00:06:24,790
whoops

141
00:06:20,740 --> 00:06:29,290
it has a rocky section and then it has

142
00:06:24,790 --> 00:06:32,050
an liquid water ocean and an icy crust

143

00:06:29,290 --> 00:06:35,080
okay due to various measurements in the

144
00:06:32,050 --> 00:06:38,310
magnetic field of motion to it we

145
00:06:35,079 --> 00:06:40,839
believe there is a liquid water ocean

146
00:06:38,310 --> 00:06:44,259
subsurface on Europa

147
00:06:40,839 --> 00:06:47,259
the question is is how thick is this ice

148
00:06:44,259 --> 00:06:49,569
layer is it 10 kilometers thick or is it

149
00:06:47,259 --> 00:06:51,430
100 kilometers thick we're not exactly

150
00:06:49,569 --> 00:06:55,060
sure there are two camps that argue

151
00:06:51,430 --> 00:06:58,209
about this but when we look at Europa's

152
00:06:55,060 --> 00:07:02,019
surface this is your opus surface we see

153
00:06:58,209 --> 00:07:04,180
a modeled ice sea surface and this is

154
00:07:02,019 --> 00:07:06,909
the famous ice rafts picture taken by

155
00:07:04,180 --> 00:07:10,060
the Galileo satellite which looks a lot

156
00:07:06,910 --> 00:07:13,930
like the broken ice structures in around

157
00:07:10,060 --> 00:07:15,668

the North Pole okay on earth indicating

158

00:07:13,930 --> 00:07:18,879

that there might be the same sort of

159

00:07:15,668 --> 00:07:21,759

motion of you know perhaps not on top of

160

00:07:18,879 --> 00:07:23,139

a shallow water layer just underneath as

161

00:07:21,759 --> 00:07:25,449

we have here on earth

162

00:07:23,139 --> 00:07:26,829

but that there might be softer ice and

163

00:07:25,449 --> 00:07:30,069

there's some sort of motion there's some

164

00:07:26,829 --> 00:07:34,449

breakup and a in motion through it okay

165

00:07:30,069 --> 00:07:38,829

we have evidence of motion of were sort

166

00:07:34,449 --> 00:07:40,300

of ice tectonics on Europa and it's look

167

00:07:38,829 --> 00:07:43,418

and it's something like this where we've

168

00:07:40,300 --> 00:07:46,270

got these subsumption bands here what we

169

00:07:43,418 --> 00:07:49,418

believe is happening is the cold outer

170

00:07:46,269 --> 00:07:51,120

ice shell is actually subducting just

171

00:07:49,418 --> 00:07:53,859

like the plates abduct on earth

172
00:07:51,120 --> 00:07:57,550
subducting below another ice layer

173
00:07:53,860 --> 00:08:00,580
alright and so this is denser and it

174
00:07:57,550 --> 00:08:03,129
drops down into the deeper warmer ice

175
00:08:00,579 --> 00:08:05,469
okay and notice that they call this the

176
00:08:03,129 --> 00:08:07,538
connecting portion of the ice shell

177
00:08:05,470 --> 00:08:10,300
alright we sort of think of ice as rigid

178
00:08:07,538 --> 00:08:12,668
and fixed but on your rope but there

179
00:08:10,300 --> 00:08:14,949
actually is motion through the ice and

180
00:08:12,668 --> 00:08:17,439
they talk about it convecting with the

181
00:08:14,949 --> 00:08:20,529
liquid ocean being underneath that ice

182
00:08:17,439 --> 00:08:23,589
layer again how thick is this ice layer

183
00:08:20,529 --> 00:08:25,869
we're not sure so it shows there is at

184
00:08:23,589 --> 00:08:28,209
least motion in the ice on your rope up

185
00:08:25,870 --> 00:08:31,629
and there's water deep underneath and

186
00:08:28,209 --> 00:08:34,870
the question is well how much that water

187
00:08:31,629 --> 00:08:37,349
gets up near the surface because if we

188
00:08:34,870 --> 00:08:40,110
want to check for life in the universe

189
00:08:37,349 --> 00:08:43,270
we need three things we need energy

190
00:08:40,110 --> 00:08:46,269
carbon and water that's what that's what

191
00:08:43,269 --> 00:08:49,179
life as we know it requires well energy

192
00:08:46,269 --> 00:08:52,059
and carbon are pretty easy to find water

193
00:08:49,179 --> 00:08:53,500
is really really hard to find so you

194
00:08:52,059 --> 00:08:54,399
rope out where we know there is some

195
00:08:53,500 --> 00:08:56,919
water

196
00:08:54,399 --> 00:08:59,649
is a place to look to see if life could

197
00:08:56,919 --> 00:09:05,349
have developed even microbial life on

198
00:08:59,649 --> 00:09:07,990
Europa alright so we have actually seen

199
00:09:05,350 --> 00:09:08,950
water plumes on another moon this is

200

00:09:07,990 --> 00:09:10,330
Saturn's moons

201
00:09:08,950 --> 00:09:12,700
Enceladus by the way this is Saturn's

202
00:09:10,330 --> 00:09:13,870
rings up here okay a nice edge on view

203
00:09:12,700 --> 00:09:15,759
of the Rings and this is from the

204
00:09:13,870 --> 00:09:18,669
Cassini satellite where you can see

205
00:09:15,759 --> 00:09:23,439
these plumes coming from Saturn's moon

206
00:09:18,669 --> 00:09:26,860
Enceladus alright and we've also seen

207
00:09:23,440 --> 00:09:31,240
indications of possible plumes on Europa

208
00:09:26,860 --> 00:09:34,060
from Hubble now Hubble did not see water

209
00:09:31,240 --> 00:09:37,990
plumes this was in 2012 what Hubble

210
00:09:34,059 --> 00:09:41,049
instead saw was auroral emissions from

211
00:09:37,990 --> 00:09:45,430
hydrogen and oxygen what is water

212
00:09:41,049 --> 00:09:48,309
composed of h₂o hydrogen and oxygen so

213
00:09:45,429 --> 00:09:51,189
these are a rural emissions associated

214
00:09:48,309 --> 00:09:53,889

with Europa from hydrogen and oxygen

215

00:09:51,190 --> 00:09:57,160

which are indicative that there might be

216

00:09:53,889 --> 00:09:59,559

water plumes so how are we going to look

217

00:09:57,159 --> 00:10:02,189

for them well we're going to be tricky

218

00:09:59,559 --> 00:10:06,159

and we're going to look for them as

219

00:10:02,190 --> 00:10:09,130

Europa goes into transit in front of

220

00:10:06,159 --> 00:10:12,669

Jupiter that way we get the bright

221

00:10:09,129 --> 00:10:17,320

background of Jupiter in order to back

222

00:10:12,669 --> 00:10:20,889

illuminate Europa in order to search for

223

00:10:17,320 --> 00:10:23,350

these plumes so here are the actual

224

00:10:20,889 --> 00:10:26,649

images from the scientific paper as

225

00:10:23,350 --> 00:10:28,200

submitted all right so this background

226

00:10:26,649 --> 00:10:34,209

here is Jupiter

227

00:10:28,200 --> 00:10:37,020

this is Europa and here are some

228

00:10:34,210 --> 00:10:40,000

evidence of plumes here's another image

229
00:10:37,019 --> 00:10:43,720
again here is Europa here's some

230
00:10:40,000 --> 00:10:46,509
evidence of plumes as I said they're not

231
00:10:43,720 --> 00:10:49,660
pretty to look at but they indicate a

232
00:10:46,509 --> 00:10:53,529
really interesting story that there

233
00:10:49,659 --> 00:10:57,219
might be water plumes spewing out of

234
00:10:53,529 --> 00:10:59,799
Europa and we can then examine that

235
00:10:57,220 --> 00:11:00,550
water to see what is going on what is

236
00:10:59,799 --> 00:11:02,709
the chemistry

237
00:11:00,549 --> 00:11:06,099
what is the details of what may be going

238
00:11:02,710 --> 00:11:07,528
on and this internal ocean which if it's

239
00:11:06,100 --> 00:11:09,659
a hundred kilometers deep

240
00:11:07,528 --> 00:11:12,688
but below a below 100 kilometers of ice

241
00:11:09,659 --> 00:11:14,639
it's gonna be really hard to get down to

242
00:11:12,688 --> 00:11:16,198
okay you want to drill down 100

243
00:11:14,639 --> 00:11:17,068
kilometers to get to get to look at

244
00:11:16,198 --> 00:11:19,588
water ocean

245
00:11:17,068 --> 00:11:21,419
that's quite an engineering challenge if

246
00:11:19,589 --> 00:11:23,459
it's ten kilometres well I think that's

247
00:11:21,419 --> 00:11:24,149
a little bit easier it's still quite the

248
00:11:23,458 --> 00:11:26,638
challenge

249
00:11:24,149 --> 00:11:29,639
if however that water that water vapour

250
00:11:26,639 --> 00:11:32,789
is spewed out from the surface that's

251
00:11:29,639 --> 00:11:34,948
much much easier so this is an exciting

252
00:11:32,789 --> 00:11:36,899
announcement it is not absolutely a

253
00:11:34,948 --> 00:11:42,299
hundred percent confirmed that it is

254
00:11:36,899 --> 00:11:44,249
water plumes there all right but it does

255
00:11:42,299 --> 00:11:46,498
look like that there are water plumes

256
00:11:44,249 --> 00:11:49,499
coming from Europa and we will continue

257

00:11:46,499 --> 00:11:52,589
to study and have more information as we

258
00:11:49,499 --> 00:11:54,870
go this is an exciting idea of where

259
00:11:52,589 --> 00:11:59,180
we're going to look for potential life

260
00:11:54,870 --> 00:12:02,669
in our solar system our second story a

261
00:11:59,179 --> 00:12:05,149
smashing finale if you were here last

262
00:12:02,669 --> 00:12:08,729
month I talked about the Rosetta mission

263
00:12:05,149 --> 00:12:10,198
and the feel a lander that is in orbit

264
00:12:08,730 --> 00:12:14,129
around the comet 67p

265
00:12:10,198 --> 00:12:16,769
churyumov-gerasimenko all right yeah

266
00:12:14,129 --> 00:12:19,759
that's quite a mouthful to say and

267
00:12:16,769 --> 00:12:23,730
Rosetta is a mission that started in

268
00:12:19,759 --> 00:12:26,879
2004 it's been going for 12 years okay

269
00:12:23,730 --> 00:12:29,519
most of that time was spent in a very

270
00:12:26,879 --> 00:12:32,278
circuitous bunch of orbits just to get

271
00:12:29,519 --> 00:12:34,528

out to match orbits with the comet

272

00:12:32,278 --> 00:12:37,139

matter of fact it did a whole bunch of

273

00:12:34,528 --> 00:12:41,519

flybys in that process so it launched in

274

00:12:37,139 --> 00:12:45,120

March of 2004 it flew by earth in 2005

275

00:12:41,519 --> 00:12:48,629

Mars in 2007 earth in late 2007 the

276

00:12:45,120 --> 00:12:53,639

asteroid Stein's in 2008 earth again in

277

00:12:48,629 --> 00:12:55,860

2009 the asteroid leticia in July 2010

278

00:12:53,639 --> 00:13:00,509

and then spent four years matching

279

00:12:55,860 --> 00:13:04,889

orbits with comet 67p CG when it got

280

00:13:00,509 --> 00:13:07,289

there it found it was a contact binary

281

00:13:04,889 --> 00:13:09,808

comet which of course earned it the

282

00:13:07,289 --> 00:13:16,049

nickname comet rubber ducky for obvious

283

00:13:09,808 --> 00:13:19,379

reasons it has then since then and since

284

00:13:16,049 --> 00:13:21,240

its arrival in August 2014 the feel a

285

00:13:19,379 --> 00:13:24,810

lander was dropped down on

286
00:13:21,240 --> 00:13:27,180
November 2014 it stayed with the comet

287
00:13:24,809 --> 00:13:29,458
through its perihelion passage its

288
00:13:27,179 --> 00:13:31,199
closes passage by the Sun which is

289
00:13:29,458 --> 00:13:33,899
generally the most active time for a

290
00:13:31,200 --> 00:13:35,700
comet alright as it goes by the Sun most

291
00:13:33,899 --> 00:13:37,139
activities is going on there and it

292
00:13:35,700 --> 00:13:40,440
stayed with it for another year later

293
00:13:37,139 --> 00:13:44,580
and the mission ended last Friday

294
00:13:40,440 --> 00:13:51,750
September 30th 2016 with a very slow

295
00:13:44,580 --> 00:13:55,950
crash landing on 67p CG now you may

296
00:13:51,750 --> 00:13:58,379
remember that feel a landing was quite

297
00:13:55,950 --> 00:14:01,980
an event it was the only scientific

298
00:13:58,379 --> 00:14:07,139
event I know of that had a live blog by

299
00:14:01,980 --> 00:14:09,959
a webcomic xkcd the author of xkcd drew

300
00:14:07,139 --> 00:14:12,929
over a hundred different pictures to

301
00:14:09,958 --> 00:14:15,359
live blog the landing of feel a over the

302
00:14:12,929 --> 00:14:16,769
course of several hours as it was going

303
00:14:15,360 --> 00:14:19,139
so you can see here's the one I chose

304
00:14:16,769 --> 00:14:22,259
from time into landing three hours and

305
00:14:19,139 --> 00:14:24,689
he has all sorts of fun information and

306
00:14:22,259 --> 00:14:25,350
makes a make some make some good science

307
00:14:24,690 --> 00:14:28,320
jokes

308
00:14:25,350 --> 00:14:31,379
if you don't know xkcd it's a very very

309
00:14:28,320 --> 00:14:32,790
geek comic okay so if you want to grow

310
00:14:31,379 --> 00:14:37,220
up to be geeks guys in the front row

311
00:14:32,789 --> 00:14:37,219
there okay you got to start reading xkcd

312
00:14:37,700 --> 00:14:44,730
the feel a lander however didn't happen

313
00:14:42,000 --> 00:14:47,250
the way it actually bounced the the the

314

00:14:44,730 --> 00:14:48,810
rockets that were were gonna the anchors

315
00:14:47,250 --> 00:14:51,958
that were gonna push into the comet

316
00:14:48,809 --> 00:14:54,599
didn't quite quite work and it was lost

317
00:14:51,958 --> 00:14:57,569
until as I showed you last month it was

318
00:14:54,600 --> 00:15:00,180
found in this little crag here the feel

319
00:14:57,570 --> 00:15:02,879
a lander was finally discovered as the

320
00:15:00,179 --> 00:15:05,458
Rosetta orbiter got close in enough to

321
00:15:02,879 --> 00:15:07,980
actually see in search for it and found

322
00:15:05,458 --> 00:15:11,789
it so there's the last resting place of

323
00:15:07,980 --> 00:15:14,060
feel a of course the Rosetta orbiter

324
00:15:11,789 --> 00:15:18,809
itself

325
00:15:14,059 --> 00:15:21,119
joined it last Friday but what if I

326
00:15:18,809 --> 00:15:23,159
remember this most about this mission is

327
00:15:21,120 --> 00:15:23,879
not going to be these images I'm going

328
00:15:23,159 --> 00:15:27,528

to show you in a minute

329

00:15:23,879 --> 00:15:31,259

but really the number of really cool

330

00:15:27,528 --> 00:15:34,139

outburst images that Rosetta was able to

331

00:15:31,259 --> 00:15:34,649

get because it stayed with the comet for

332

00:15:34,139 --> 00:15:37,110

a year

333

00:15:34,649 --> 00:15:40,110

for perihelion and a year after

334

00:15:37,110 --> 00:15:42,089

perihelion covering this active time in

335

00:15:40,110 --> 00:15:44,278

a life of the comet you can see all of

336

00:15:42,089 --> 00:15:46,949

these outbursts it was able to capture

337

00:15:44,278 --> 00:15:49,649

this is an immense data set that we will

338

00:15:46,948 --> 00:15:50,639

look at for years and and and even

339

00:15:49,649 --> 00:15:53,669

decades to come

340

00:15:50,639 --> 00:15:55,919

yes that was in The Wall Street The Wall

341

00:15:53,669 --> 00:15:57,479

Street Journal covered the the outburst

342

00:15:55,919 --> 00:16:03,628

because this is one of the great montage

343
00:15:57,480 --> 00:16:06,319
images well I'm glad to hear the Wall

344
00:16:03,629 --> 00:16:09,720
Street Journal Street Journal covers

345
00:16:06,318 --> 00:16:13,828
great science because this is an amazing

346
00:16:09,720 --> 00:16:15,540
amount of just amazing amount of

347
00:16:13,828 --> 00:16:18,388
observations compared to what we've had

348
00:16:15,539 --> 00:16:20,248
in terms of covering outbursts on comets

349
00:16:18,389 --> 00:16:23,549
okay and this this data set will be

350
00:16:20,249 --> 00:16:26,189
mined for years to come okay so they

351
00:16:23,549 --> 00:16:29,308
took 15 image they released 15 images of

352
00:16:26,188 --> 00:16:31,469
the descent of Rosetta over the last 24

353
00:16:29,308 --> 00:16:33,688
hours so in the lower-left this is the

354
00:16:31,470 --> 00:16:35,850
time to impact 23 hours 30 minutes for

355
00:16:33,688 --> 00:16:38,039
this first image and here's the height

356
00:16:35,850 --> 00:16:40,759
above the center of the comet 22.9

357
00:16:38,039 --> 00:16:40,759
kilometers

358
00:16:41,850 --> 00:16:44,850
and this is just a counting number so I

359
00:16:43,289 --> 00:16:46,919
can keep track

360
00:16:44,850 --> 00:16:48,720
downloading 15 images and keeping them

361
00:16:46,919 --> 00:16:50,878
the correct orders never caught in there

362
00:16:48,720 --> 00:16:53,459
oh it's not that easy alright so here

363
00:16:50,879 --> 00:16:55,499
you can see that a day before it's still

364
00:16:53,458 --> 00:16:58,289
you know you're seeing pretty much the

365
00:16:55,499 --> 00:16:59,790
comment you've got a you know a full

366
00:16:58,289 --> 00:17:01,198
sized view of the comment and you can

367
00:16:59,789 --> 00:17:03,269
see it's orbiting around the comet in

368
00:17:01,198 --> 00:17:06,629
the comet itself is turning the comet

369
00:17:03,269 --> 00:17:08,490
nucleus and as we start to get in now

370
00:17:06,630 --> 00:17:11,640
we're down just a little bit closer at

371

00:17:08,490 --> 00:17:13,500
20 kilometers and also these images go

372
00:17:11,640 --> 00:17:15,870
from the wide-angle view to the narrow

373
00:17:13,500 --> 00:17:17,308
angle view here you've got and start to

374
00:17:15,869 --> 00:17:19,019
see that you can see they're very craggy

375
00:17:17,308 --> 00:17:23,189
surface almost feels like it's sharp

376
00:17:19,019 --> 00:17:26,129
okay surface moving in you can see the

377
00:17:23,189 --> 00:17:28,649
sort of steps across there really

378
00:17:26,130 --> 00:17:30,179
interesting structures and then you've

379
00:17:28,648 --> 00:17:32,219
got a series of couple images where you

380
00:17:30,179 --> 00:17:35,190
can see this the same structures these

381
00:17:32,220 --> 00:17:37,380
are just relatively close in time you

382
00:17:35,190 --> 00:17:40,528
can see that structure here and you can

383
00:17:37,380 --> 00:17:43,679
see the structures it was moving through

384
00:17:40,528 --> 00:17:45,659
here then we get the what I think is the

385
00:17:43,679 --> 00:17:46,990

coolest image so we've been looking down

386

00:17:45,659 --> 00:17:50,830

on this

387

00:17:46,990 --> 00:17:52,120

then we get this image which looks like

388

00:17:50,829 --> 00:17:54,970

you're down on the surface of the comet

389

00:17:52,119 --> 00:17:57,519

right but what it has to be because

390

00:17:54,970 --> 00:17:59,860

you're 16 kilometers away from the comet

391

00:17:57,519 --> 00:18:02,230

this is the narrow angle camera right

392

00:17:59,859 --> 00:18:04,209

but what it has to be is whoops let me

393

00:18:02,230 --> 00:18:07,329

go back is that you're looking at one of

394

00:18:04,210 --> 00:18:09,220

these crags here from the side okay so

395

00:18:07,329 --> 00:18:11,829

as it orbits around the comet it's

396

00:18:09,220 --> 00:18:14,380

looking directly along here and you're

397

00:18:11,829 --> 00:18:16,449

looking in to see these crags sticking

398

00:18:14,380 --> 00:18:18,429

up and I actually think this is the

399

00:18:16,450 --> 00:18:21,400

coolest image of all of all the series

400
00:18:18,429 --> 00:18:23,740
of 15 because it just sort of gets you a

401
00:18:21,400 --> 00:18:25,210
feeling like you are there if you don't

402
00:18:23,740 --> 00:18:28,599
almost feel like you're walking on on

403
00:18:25,210 --> 00:18:30,100
the surface of the comet nucleus so this

404
00:18:28,599 --> 00:18:35,500
is kind of fun it looks a little bit

405
00:18:30,099 --> 00:18:40,539
like what's the there's a national park

406
00:18:35,500 --> 00:18:42,279
in the southwest Bryce Canyon that's it

407
00:18:40,539 --> 00:18:44,139
Bryce Canyon has a little bit of the

408
00:18:42,279 --> 00:18:48,849
hoodoo feel of Bryce Canyon National

409
00:18:44,140 --> 00:18:50,350
Park but Bryce Canyon doesn't it doesn't

410
00:18:48,849 --> 00:18:55,079
look that that rocky and in that case

411
00:18:50,349 --> 00:18:57,189
anyways so there is no erosion right

412
00:18:55,079 --> 00:18:59,230
exactly it couldn't be

413
00:18:57,190 --> 00:19:00,820
you couldn't have real hoodoos here

414
00:18:59,230 --> 00:19:03,808
because you wouldn't because dollars are

415
00:19:00,819 --> 00:19:06,609
produced by water erosion creating them

416
00:19:03,808 --> 00:19:08,109
this is I'm not an expert on the on this

417
00:19:06,609 --> 00:19:09,009
okay matter of fact I'll show you how

418
00:19:08,109 --> 00:19:10,449
much I'm an honor an expert because

419
00:19:09,009 --> 00:19:12,609
they've got a couple images here that

420
00:19:10,450 --> 00:19:14,799
I'm not exactly sure why they look like

421
00:19:12,609 --> 00:19:16,599
this either okay

422
00:19:14,799 --> 00:19:18,659
and then you can see as we're getting

423
00:19:16,599 --> 00:19:22,178
closer we're nine hours before impact

424
00:19:18,660 --> 00:19:23,980
okay and then we jump to almost six

425
00:19:22,179 --> 00:19:25,960
hours for impact and here you can again

426
00:19:23,980 --> 00:19:28,089
see these sort of striations structures

427
00:19:25,960 --> 00:19:29,829
okay which to me look like sedimentary

428

00:19:28,089 --> 00:19:31,899
stuff and I know it's not sedimentary

429
00:19:29,829 --> 00:19:34,119
stuff maybe it's produced by the

430
00:19:31,900 --> 00:19:37,690
collision of those to contact binary

431
00:19:34,119 --> 00:19:39,279
objects that form the contact binary so

432
00:19:37,690 --> 00:19:41,370
you've got this sort of striated stuff

433
00:19:39,279 --> 00:19:45,160
and then you get this sort of leather

434
00:19:41,369 --> 00:19:47,049
leathery type plane here okay and we

435
00:19:45,160 --> 00:19:48,759
have a lot of this type of plane that

436
00:19:47,049 --> 00:19:53,289
that we zooming in we're down 3 hours

437
00:19:48,759 --> 00:19:56,079
before impact ok moving in here here is

438
00:19:53,289 --> 00:19:58,269
the target area for where they're going

439
00:19:56,079 --> 00:20:00,490
to land it you can see that cliff along

440
00:19:58,269 --> 00:20:03,279
here three hours before impact

441
00:20:00,490 --> 00:20:05,440
six kilometers about the surface down to

442
00:20:03,279 --> 00:20:07,660

one point two kilometers you can see an

443

00:20:05,440 --> 00:20:09,460

edge with this very sharp sharp shadow

444

00:20:07,660 --> 00:20:12,850

here all right you're seeing the details

445

00:20:09,460 --> 00:20:15,850

and then the final image one minute

446

00:20:12,849 --> 00:20:18,459

before impact this is from 20 meters

447

00:20:15,849 --> 00:20:22,329

height I'm told this is about one meter

448

00:20:18,460 --> 00:20:24,340

across on the comet so it's out of focus

449

00:20:22,329 --> 00:20:28,329

because the cameras were never meant to

450

00:20:24,339 --> 00:20:31,629

focus 20 meters away from it and then

451

00:20:28,329 --> 00:20:35,289

boom the res that a signal was lost

452

00:20:31,630 --> 00:20:40,240

11:19 GMT here is the signal and there

453

00:20:35,289 --> 00:20:43,740

is not okay so the Rosetta mission will

454

00:20:40,240 --> 00:20:46,569

live on through it's amazing data set

455

00:20:43,740 --> 00:20:49,930

when I tweeted about this I said Rosetta

456

00:20:46,569 --> 00:20:55,119

is dead long live Rosetta because it

457
00:20:49,930 --> 00:20:58,150
really will have an amazing impact on

458
00:20:55,119 --> 00:21:01,269
cometary science however it will not

459
00:20:58,150 --> 00:21:03,460
have the kind of impact that people talk

460
00:21:01,269 --> 00:21:07,089
about in Hollywood movies so I'm gonna

461
00:21:03,460 --> 00:21:09,759
give the last word to xkcd who put out a

462
00:21:07,089 --> 00:21:10,859
Rosetta comic on Friday you can read it

463
00:21:09,759 --> 00:21:13,900
for yourself

464
00:21:10,859 --> 00:21:16,929
and it references the movie Armageddon

465
00:21:13,900 --> 00:21:20,019
in which they did try to blow up a

466
00:21:16,930 --> 00:21:21,940
comment to deflect it this was not meant

467
00:21:20,019 --> 00:21:26,279
to deflect the comet Bruce Willis was

468
00:21:21,940 --> 00:21:36,789
not required on the Rosetta mission okay

469
00:21:26,279 --> 00:21:40,629
any questions for yes okay so as the

470
00:21:36,789 --> 00:21:43,000
comet approaches the Sun it heats up and

471
00:21:40,630 --> 00:21:47,920
any pockets of volatiles that are near

472
00:21:43,000 --> 00:21:48,490
the surface can can it can can go from

473
00:21:47,920 --> 00:21:51,759
there

474
00:21:48,490 --> 00:21:54,039
isis state to gaseous state and blow out

475
00:21:51,759 --> 00:21:55,990
as Jets that's very common on comets

476
00:21:54,039 --> 00:21:59,470
matter of fact the what you're looking

477
00:21:55,990 --> 00:22:01,870
at with the 67p CG mostly is the comet

478
00:21:59,470 --> 00:22:04,059
nucleus okay but what you usually think

479
00:22:01,869 --> 00:22:06,519
of the knew of a comet is this big fuzzy

480
00:22:04,059 --> 00:22:08,799
ball well that's the coma that's all the

481
00:22:06,519 --> 00:22:11,049
gases that have have come out from the

482
00:22:08,799 --> 00:22:14,058
comet all right and then you get that

483
00:22:11,049 --> 00:22:15,739
those gases get swept back into a tail

484
00:22:14,058 --> 00:22:18,259
and that's what produces your standard

485

00:22:15,739 --> 00:22:21,409
idea of a comment what we're studying

486
00:22:18,259 --> 00:22:24,200
here is really the comet nucleus and

487
00:22:21,409 --> 00:22:26,659
those outbursts are the gases that are

488
00:22:24,200 --> 00:22:30,528
that are bursting out it the perihelion

489
00:22:26,659 --> 00:22:32,989
for 67p is only one point two times the

490
00:22:30,528 --> 00:22:34,749
Earth's distance to the Sun so it never

491
00:22:32,989 --> 00:22:38,210
gets really really close to the Sun

492
00:22:34,749 --> 00:22:40,190
therefore it doesn't doesn't burst out

493
00:22:38,210 --> 00:22:42,019
that much and it doesn't produce a coma

494
00:22:40,190 --> 00:22:45,200
it's a short period comet only has a six

495
00:22:42,019 --> 00:22:47,329
point four year period so it doesn't

496
00:22:45,200 --> 00:22:50,749
develop a big long tail like you may

497
00:22:47,329 --> 00:22:53,088
have seen with comet hale-bopp or the

498
00:22:50,749 --> 00:22:54,769
way we depict comet West or comet

499
00:22:53,088 --> 00:22:57,678

aquellas ecchi or other of these

500

00:22:54,769 --> 00:22:59,479

spectacular comets this is just your

501

00:22:57,679 --> 00:23:00,048

normal ordinary run-of-the-mill boring

502

00:22:59,479 --> 00:23:02,088

comet

503

00:23:00,048 --> 00:23:04,759

sorry most comets are actually kind of

504

00:23:02,088 --> 00:23:07,428

boring they are that ice ball nucleus

505

00:23:04,759 --> 00:23:09,499

with the Jets coming out and not these

506

00:23:07,429 --> 00:23:11,690

big huge tails that last that stretch

507

00:23:09,499 --> 00:23:17,778

for millions of kilometres good question

508

00:23:11,690 --> 00:23:19,879

thank you yes it's ice and rock it's ice

509

00:23:17,778 --> 00:23:21,710

and rock I usually usually think of them

510

00:23:19,878 --> 00:23:34,189

as ice balls but we know if we actually

511

00:23:21,710 --> 00:23:38,269

know yes they are ice and rock yes it

512

00:23:34,190 --> 00:23:40,729

could be I say it does look a lot like

513

00:23:38,269 --> 00:23:42,919

rocks scatter and you will expose my

514
00:23:40,729 --> 00:23:45,700
ignorance on the commentary services

515
00:23:42,919 --> 00:23:48,469
we've never seen commentary surfaces and

516
00:23:45,700 --> 00:23:51,679
that incredible detail we actually you

517
00:23:48,469 --> 00:23:53,179
know with Pluto last year and the the

518
00:23:51,679 --> 00:23:55,639
Deep Impact mission that we did a few

519
00:23:53,179 --> 00:23:57,528
years ago and this we're learning so

520
00:23:55,638 --> 00:23:59,538
much and actually what we're seeing on

521
00:23:57,528 --> 00:24:02,960
Europa as well we're learning so much

522
00:23:59,538 --> 00:24:05,088
about Isis and how they behave out in

523
00:24:02,960 --> 00:24:06,319
the solar system we're just seeing you

524
00:24:05,088 --> 00:24:10,178
know cryovolcanism

525
00:24:06,319 --> 00:24:15,648
on on Pluto the kraaho tectonics on

526
00:24:10,179 --> 00:24:17,599
Europa and so how these ices interact is

527
00:24:15,648 --> 00:24:20,118
something that that's actually pretty

528
00:24:17,598 --> 00:24:21,259
new and I think it's a quite an

529
00:24:20,118 --> 00:24:22,118
interesting field that has developed

530
00:24:21,259 --> 00:24:25,729
lately

531
00:24:22,118 --> 00:24:27,138
alright I well I have to I have to get

532
00:24:25,729 --> 00:24:27,940
to Bill's talk otherwise we'll be here

533
00:24:27,138 --> 00:24:30,369
wait

534
00:24:27,940 --> 00:24:33,460
late alright so let me go to our

535
00:24:30,369 --> 00:24:36,008
featured speaker and our featured

536
00:24:33,460 --> 00:24:39,069
speaker tonight is Bill Blair from the

537
00:24:36,009 --> 00:24:40,899
Johns Hopkins University and it is Johns

538
00:24:39,069 --> 00:24:44,048
Hopkins make sure everybody in Baltimore

539
00:24:40,898 --> 00:24:47,018
knows that okay bill has been there and

540
00:24:44,048 --> 00:24:48,940
he told me since 1984 and I was like he

541
00:24:47,019 --> 00:24:50,878
doesn't look old enough to have been

542

00:24:48,940 --> 00:24:57,820
around since my teenager

543
00:24:50,878 --> 00:25:00,579
yes he got his PhD at 12 he has worked

544
00:24:57,819 --> 00:25:02,918
on several major instruments the Hopkins

545
00:25:00,579 --> 00:25:05,109
ultraviolet telescope that flew on the

546
00:25:02,919 --> 00:25:06,669
Space Shuttle twice we had hoped it

547
00:25:05,109 --> 00:25:09,250
would fly a few more times on the space

548
00:25:06,669 --> 00:25:12,250
shuttle and then he moved over to the

549
00:25:09,250 --> 00:25:16,000
Far all Tobias copic Explorer also

550
00:25:12,250 --> 00:25:19,269
called fuse working in as you can see in

551
00:25:16,000 --> 00:25:21,788
ultraviolet and now he has moved to

552
00:25:19,269 --> 00:25:24,490
infrared he most of his time is spent

553
00:25:21,788 --> 00:25:29,109
now on the James Webb Space Telescope

554
00:25:24,490 --> 00:25:30,399
and I don't know what else to say it

555
00:25:29,109 --> 00:25:33,069
he's a really great guy I think you're

556
00:25:30,398 --> 00:25:36,388

gonna enjoy his talk tonight ladies and

557

00:25:33,069 --> 00:25:36,388

gentlemen dr. bill Blair

558

00:25:39,099 --> 00:25:45,409

thank you very much it's a great

559

00:25:42,019 --> 00:25:47,000

pleasure to be here tonight to tell you

560

00:25:45,410 --> 00:25:49,519

about some research that I've been

561

00:25:47,000 --> 00:25:51,019

involved with most of my effort these

562

00:25:49,519 --> 00:25:53,359

days is functional work I'm actually

563

00:25:51,019 --> 00:25:55,670

working to help the Institute prepare

564

00:25:53,359 --> 00:25:58,099

for the James Webb telescope and prepare

565

00:25:55,670 --> 00:25:59,930

the the ground system is called the

566

00:25:58,099 --> 00:26:02,059

software and the systems that will

567

00:25:59,930 --> 00:26:04,519

support the James Webb telescope and

568

00:26:02,059 --> 00:26:07,549

astronomers - proposed for the James

569

00:26:04,519 --> 00:26:09,529

Webb telescope and so most of my effort

570

00:26:07,549 --> 00:26:11,389

is in meetings and that kind of stuff

571
00:26:09,529 --> 00:26:13,160
now but I do have a bunch of good

572
00:26:11,390 --> 00:26:15,800
collaborators and and over the last six

573
00:26:13,160 --> 00:26:17,690
or seven years we're partway through a

574
00:26:15,799 --> 00:26:19,309
research project that I'll eventually

575
00:26:17,690 --> 00:26:20,809
get to tonight I want to tell you some

576
00:26:19,309 --> 00:26:23,869
other things first before we get there

577
00:26:20,809 --> 00:26:26,119
on this galaxy m83 and in the background

578
00:26:23,869 --> 00:26:29,629
here you see what is a large mosaic

579
00:26:26,119 --> 00:26:31,039
image from the Hubble telescope some of

580
00:26:29,630 --> 00:26:34,580
the one the datasets that we took for

581
00:26:31,039 --> 00:26:36,920
this project to help us look for look at

582
00:26:34,579 --> 00:26:38,839
the star formation great huge amounts of

583
00:26:36,920 --> 00:26:41,269
star formation huge amounts of star

584
00:26:38,839 --> 00:26:43,519
formation going on in here and and then

585
00:26:41,269 --> 00:26:45,529
find the supernova remnants which is the

586
00:26:43,519 --> 00:26:47,450
stellar life the birth and evolution of

587
00:26:45,529 --> 00:26:48,019
stars and then the stellar gases the

588
00:26:47,450 --> 00:26:50,930
backend

589
00:26:48,019 --> 00:26:52,069
the supernova supernovae and the

590
00:26:50,930 --> 00:26:55,730
remnants the things that they leave

591
00:26:52,069 --> 00:26:58,129
behind and we try to study that galaxy

592
00:26:55,730 --> 00:27:00,259
and put it in context with our own Milky

593
00:26:58,130 --> 00:27:04,450
Way galaxy and other galaxies here in

594
00:27:00,259 --> 00:27:08,809
our local group for instance okay so

595
00:27:04,450 --> 00:27:10,640
before get to the the the meat of things

596
00:27:08,809 --> 00:27:12,950
here with the star formation and

597
00:27:10,640 --> 00:27:15,050
supernova remnants I want to spend a

598
00:27:12,950 --> 00:27:18,049
couple minutes giving you some context

599

00:27:15,049 --> 00:27:19,720
and tell you about how we find the

600
00:27:18,049 --> 00:27:22,669
supernova remnants in other galaxies

601
00:27:19,720 --> 00:27:24,049
we'll talk about what we see locally and

602
00:27:22,670 --> 00:27:27,980
what we're trying to find as we look

603
00:27:24,049 --> 00:27:30,289
farther away and then we'll get into m83

604
00:27:27,980 --> 00:27:35,690
itself and what we are finding and some

605
00:27:30,289 --> 00:27:38,450
ideas of of what it might might mean so

606
00:27:35,690 --> 00:27:40,100
part of the context I like to do I like

607
00:27:38,450 --> 00:27:42,920
to try to do a few things to make big

608
00:27:40,099 --> 00:27:44,599
numbers understandable you know we hear

609
00:27:42,920 --> 00:27:46,160
so much you know in the public domain

610
00:27:44,599 --> 00:27:48,169
these days we hear millions and billions

611
00:27:46,160 --> 00:27:49,550
and trillions thrown around and they're

612
00:27:48,170 --> 00:27:51,650
just big numbers we just don't

613
00:27:49,549 --> 00:27:53,720

understand how big number

614

00:27:51,650 --> 00:27:55,220

really are and in astronomy of course we

615

00:27:53,720 --> 00:27:57,860

have to deal with a lot of big numbers

616

00:27:55,220 --> 00:28:00,470

we have the problem of distances I mean

617

00:27:57,859 --> 00:28:03,049

one light-year our yardstick that we use

618

00:28:00,470 --> 00:28:05,900

in in astronomy is some six trillion

619

00:28:03,049 --> 00:28:09,169

miles six times ten to the twelfth a six

620

00:28:05,900 --> 00:28:11,630

with 12 zeros miles in one light year

621

00:28:09,170 --> 00:28:14,180

and the nearest star is 4.3 light years

622

00:28:11,630 --> 00:28:16,720

away but the distances to quasars and

623

00:28:14,180 --> 00:28:19,070

galaxies are millions or billions of

624

00:28:16,720 --> 00:28:21,259

light-years and so these are just big

625

00:28:19,069 --> 00:28:23,509

numbers they kind of lose their context

626

00:28:21,259 --> 00:28:25,430

the same thing with discussion in the

627

00:28:23,509 --> 00:28:27,710

public domain when we talk about budgets

628
00:28:25,430 --> 00:28:29,180
and and this kind of thing and I think

629
00:28:27,710 --> 00:28:31,220
part of the problem is you know we kind

630
00:28:29,180 --> 00:28:32,690
of here million billion trillion and we

631
00:28:31,220 --> 00:28:34,730
think they're kind of factors of 10

632
00:28:32,690 --> 00:28:37,190
apart but they're not they're factors of

633
00:28:34,730 --> 00:28:39,380
a thousand apart you know it's a

634
00:28:37,190 --> 00:28:42,529
thousand millions make a billion and a

635
00:28:39,380 --> 00:28:44,930
thousand billions to make a trillion

636
00:28:42,529 --> 00:28:47,539
okay so I thought I would just do a

637
00:28:44,930 --> 00:28:51,830
little exercise to give you some idea of

638
00:28:47,539 --> 00:28:55,460
how big a billion is okay so I have some

639
00:28:51,829 --> 00:28:56,779
props here I have a ream of paper I want

640
00:28:55,460 --> 00:28:59,180
you to use your imagination here a

641
00:28:56,779 --> 00:29:00,889
little bit okay so Rina Rina paper has

642
00:28:59,180 --> 00:29:05,630
how many how many sheets of paper in a

643
00:29:00,890 --> 00:29:08,570
ream you know 500 500 sheets okay let's

644
00:29:05,630 --> 00:29:10,150
assume every sheet of paper in here is a

645
00:29:08,569 --> 00:29:13,460
hundred dollar bill

646
00:29:10,150 --> 00:29:15,259
okay so we got 500 hundred dollar bills

647
00:29:13,460 --> 00:29:19,370
that's 50 thousand dollars right there

648
00:29:15,259 --> 00:29:20,930
okay so if I take two of those we got a

649
00:29:19,369 --> 00:29:23,119
hundred thousand dollars so that's a

650
00:29:20,930 --> 00:29:26,269
little easier to go by factors of 10

651
00:29:23,119 --> 00:29:28,969
from so there's two there's a hundred

652
00:29:26,269 --> 00:29:32,660
thousand dollars \$100 bills side by side

653
00:29:28,970 --> 00:29:35,150
and I got a yardstick here that happens

654
00:29:32,660 --> 00:29:40,100
to be about four inches okay so four

655
00:29:35,150 --> 00:29:43,640
inches of paper is like \$100,000 so ten

656

00:29:40,099 --> 00:29:44,959
times that is a million dollars okay if

657
00:29:43,640 --> 00:29:47,840
we had the stack of paper that high

658
00:29:44,960 --> 00:29:50,210
that's a meter stick 40 inches that

659
00:29:47,839 --> 00:29:52,069
would be a million dollars so \$100 bills

660
00:29:50,210 --> 00:29:55,670
stacked up to there there's a million

661
00:29:52,069 --> 00:30:00,730
dollars a billion dollars is a thousand

662
00:29:55,670 --> 00:30:02,538
times that a kilometer 6/10 of a mile

663
00:30:00,730 --> 00:30:04,639
okay

664
00:30:02,538 --> 00:30:06,108
so when you're here so you still I could

665
00:30:04,638 --> 00:30:08,748
pick a random number out of the you know

666
00:30:06,108 --> 00:30:13,069
the the news you know nine hundred

667
00:30:08,749 --> 00:30:15,709
thirteen million that's over half a mile

668
00:30:13,069 --> 00:30:17,028
high stack of \$100 bills folks so that's

669
00:30:15,709 --> 00:30:19,669
that's a big number

670
00:30:17,028 --> 00:30:21,709

okay big numbers that so let's do one

671

00:30:19,669 --> 00:30:23,599

more thing let's go one more step look

672

00:30:21,709 --> 00:30:25,339

instead of money let's talk about time

673

00:30:23,598 --> 00:30:27,828

because time is another thing in

674

00:30:25,338 --> 00:30:29,868

astronomy that gets pretty pretty hairy

675

00:30:27,828 --> 00:30:31,999

for us and it's because there's such a

676

00:30:29,868 --> 00:30:33,588

dichotomy between our experience of time

677

00:30:31,999 --> 00:30:37,489

we're like a hundred years is a long

678

00:30:33,588 --> 00:30:40,368

time to us but to realize that a million

679

00:30:37,489 --> 00:30:42,769

years or in some context even a billion

680

00:30:40,368 --> 00:30:45,259

years in astronomy is considered a short

681

00:30:42,769 --> 00:30:48,378

time because this universe itself is

682

00:30:45,259 --> 00:30:50,989

13.8 billion years and so you're looking

683

00:30:48,378 --> 00:30:52,998

at the evolution of galaxies from early

684

00:30:50,989 --> 00:30:54,528

times on you know a billion years is

685
00:30:52,999 --> 00:30:57,078
really not that long

686
00:30:54,528 --> 00:30:58,759
believe it or not right so we could do

687
00:30:57,078 --> 00:31:00,948
that same thing let's take one sheet of

688
00:30:58,759 --> 00:31:03,068
paper and this is now a time line okay

689
00:31:00,949 --> 00:31:05,449
one sheet of paper is a hundred years a

690
00:31:03,068 --> 00:31:08,418
like a human lifetime a long human

691
00:31:05,449 --> 00:31:12,169
lifetime okay well then a million years

692
00:31:08,419 --> 00:31:16,729
is that big and a billion years is the

693
00:31:12,169 --> 00:31:20,179
6/10 of a mile one kilometer tall so

694
00:31:16,729 --> 00:31:22,639
this is a short time in astronomy one

695
00:31:20,179 --> 00:31:24,589
sheet of paper is a long time to us and

696
00:31:22,638 --> 00:31:27,078
that's why we sometimes have a hard time

697
00:31:24,588 --> 00:31:29,028
communicating these big these big

698
00:31:27,078 --> 00:31:32,598
numbers well so now we're going to look

699
00:31:29,028 --> 00:31:34,398
at star formation in m83 you collapsed a

700
00:31:32,598 --> 00:31:35,568
cloud of gas and dust it creates a whole

701
00:31:34,398 --> 00:31:38,928
bunch of stars there are a whole range

702
00:31:35,568 --> 00:31:41,499
of different masses the big massive

703
00:31:38,929 --> 00:31:43,849
stars only live for a few million years

704
00:31:41,499 --> 00:31:45,649
short time ok

705
00:31:43,848 --> 00:31:47,239
whereas I mean our Sun we know is

706
00:31:45,648 --> 00:31:48,738
four-and-a-half billion years there's

707
00:31:47,239 --> 00:31:51,499
only maybe about halfway through its

708
00:31:48,739 --> 00:31:53,929
lifetime so the low mass stars that form

709
00:31:51,499 --> 00:31:56,358
will stay around almost almost forever

710
00:31:53,929 --> 00:31:58,489
from an evolutionary standpoint for the

711
00:31:56,358 --> 00:32:00,138
galaxies standpoint whereas it's the

712
00:31:58,489 --> 00:32:03,949
most massive stars the ones that live

713

00:32:00,138 --> 00:32:06,258
live live fast and die young that that

714
00:32:03,949 --> 00:32:09,019
create most of the energising of the

715
00:32:06,259 --> 00:32:11,088
interstellar gas forcing new star

716
00:32:09,019 --> 00:32:13,219
formation to happen as those shockwaves

717
00:32:11,088 --> 00:32:14,868
from the supernova impact clouds of gas

718
00:32:13,219 --> 00:32:16,400
and dust and make them collapse and so

719
00:32:14,868 --> 00:32:18,319
forth so I'll

720
00:32:16,400 --> 00:32:21,290
probably mostly concentrate on the more

721
00:32:18,319 --> 00:32:23,089
massive stars and supernova remnants

722
00:32:21,289 --> 00:32:27,379
that come from those masters stars as we

723
00:32:23,089 --> 00:32:29,750
go on through the talk the other piece

724
00:32:27,380 --> 00:32:32,090
of context I wanted to give you is we

725
00:32:29,750 --> 00:32:33,650
all love these beautiful color pictures

726
00:32:32,089 --> 00:32:36,169
that we get out of Hubble and out of

727
00:32:33,650 --> 00:32:38,060

other missions as well and I wanted to

728

00:32:36,170 --> 00:32:40,430

put that in context a little bit as well

729

00:32:38,059 --> 00:32:42,589

this is the Kepler supernova remnant it

730

00:32:40,430 --> 00:32:46,009

came from an explosion that Johannes

731

00:32:42,589 --> 00:32:47,899

Kepler observed in 1604 one of my

732

00:32:46,009 --> 00:32:50,150

favorite objects here and what we're

733

00:32:47,900 --> 00:32:52,820

looking at in this color picture is

734

00:32:50,150 --> 00:32:55,220

actually a combination of Chandra x-ray

735

00:32:52,819 --> 00:32:57,349

data two different colors here blue in

736

00:32:55,220 --> 00:32:59,210

the green in this picture this is harder

737

00:32:57,349 --> 00:33:01,730

x-rays that show you the kind of the

738

00:32:59,210 --> 00:33:04,759

outer rim is the brightest that's the

739

00:33:01,730 --> 00:33:06,769

shock wave and the hardest x-rays the

740

00:33:04,759 --> 00:33:09,379

green is a little bit interior to that

741

00:33:06,769 --> 00:33:12,829

that is the actual ejecta the star stuff

742
00:33:09,380 --> 00:33:15,290
from the supernova that exploded okay

743
00:33:12,829 --> 00:33:17,269
the yellow which I'll show in more

744
00:33:15,289 --> 00:33:19,220
detail on the other side here but you

745
00:33:17,269 --> 00:33:20,990
see the yellow in here is the densest

746
00:33:19,220 --> 00:33:22,819
clumps of stuff that's what Hubble sees

747
00:33:20,990 --> 00:33:25,400
is the really dead stuff in the optical

748
00:33:22,819 --> 00:33:26,929
so the yellow is Hubble and this is one

749
00:33:25,400 --> 00:33:28,880
wavelength of infrared emission from the

750
00:33:26,930 --> 00:33:31,700
Spitzer Space Telescope it's actually

751
00:33:28,880 --> 00:33:33,590
showing us warm dust that is heated by

752
00:33:31,700 --> 00:33:35,809
the shockwave and you see how it's

753
00:33:33,589 --> 00:33:38,689
one-sided how one side of this structure

754
00:33:35,809 --> 00:33:41,690
is really dominant in the heated dust

755
00:33:38,690 --> 00:33:43,190
and that's it turns out putting all this

756
00:33:41,690 --> 00:33:45,500
together like this is telling us that

757
00:33:43,190 --> 00:33:47,539
the shockwave was running up a density

758
00:33:45,500 --> 00:33:50,420
gradient it's denser up there in the

759
00:33:47,539 --> 00:33:52,069
upper right and the dust is denser and

760
00:33:50,420 --> 00:33:55,180
it's getting heated up by the shockwave

761
00:33:52,069 --> 00:33:57,649
is that impinges on that denser material

762
00:33:55,180 --> 00:33:59,450
so again looking at things at different

763
00:33:57,650 --> 00:34:02,600
wavelengths one of the points here is

764
00:33:59,450 --> 00:34:05,509
that supernova remnants observe across

765
00:34:02,599 --> 00:34:07,339
the light spectrum from x-ray all the

766
00:34:05,509 --> 00:34:08,960
way out to radio I don't have radio on

767
00:34:07,339 --> 00:34:12,380
here but they're strong radio sources as

768
00:34:08,960 --> 00:34:14,599
well infrared optical ultraviolet across

769
00:34:12,380 --> 00:34:15,919
the spectrum they're very multi

770

00:34:14,599 --> 00:34:18,259
wavelength and so that's right I'm

771
00:34:15,918 --> 00:34:21,168
taking a multi wavelength approach to

772
00:34:18,260 --> 00:34:22,490
look at this galaxy m83 we have to look

773
00:34:21,168 --> 00:34:24,049
at different wavelengths to find the

774
00:34:22,489 --> 00:34:25,459
ones that are bright and x-ray versus

775
00:34:24,050 --> 00:34:27,909
the ones that are bright optically and

776
00:34:25,460 --> 00:34:27,909
so forth

777
00:34:28,639 --> 00:34:32,309
okay so when we make these color

778
00:34:30,690 --> 00:34:33,929
pictures like it's kind of I kind knows

779
00:34:32,309 --> 00:34:37,980
this but I just wanted to point out that

780
00:34:33,929 --> 00:34:40,619
you know if I make one one image in red

781
00:34:37,980 --> 00:34:42,990
one image in green and one image in blue

782
00:34:40,619 --> 00:34:44,638
then where things are bright in more

783
00:34:42,989 --> 00:34:47,128
than one band you get different colors

784
00:34:44,639 --> 00:34:49,320

okay if it's bright and the blue and the

785

00:34:47,128 --> 00:34:51,389

red you get this kind of pinky magenta

786

00:34:49,320 --> 00:34:53,429

color if you if it's bright and blue and

787

00:34:51,389 --> 00:34:55,230

green you get that cyan color and if

788

00:34:53,429 --> 00:34:57,300

it's bright in red and green you get

789

00:34:55,230 --> 00:34:59,639

yellow and so if I make a color image

790

00:34:57,300 --> 00:35:01,440

out of three different images of

791

00:34:59,639 --> 00:35:03,989

different wavelengths of light or

792

00:35:01,440 --> 00:35:05,400

different data from different

793

00:35:03,989 --> 00:35:08,250

instruments like we just looked at from

794

00:35:05,400 --> 00:35:10,079

Chandra and from Hubble and so forth you

795

00:35:08,250 --> 00:35:11,429

can compare the similarities and

796

00:35:10,079 --> 00:35:12,900

differences by looking at the colors

797

00:35:11,429 --> 00:35:14,460

where they're both bright

798

00:35:12,900 --> 00:35:16,050

that's one of the tricks we play and

799

00:35:14,460 --> 00:35:18,150

then over here I just show that

800

00:35:16,050 --> 00:35:19,560

basically it's not an on/off thing like

801

00:35:18,150 --> 00:35:21,570

this it's basically there's all kinds of

802

00:35:19,559 --> 00:35:23,659

gradation in the color that you get as

803

00:35:21,570 --> 00:35:26,039

you combine those in different amounts

804

00:35:23,659 --> 00:35:28,710

so as we make color pictures we can

805

00:35:26,039 --> 00:35:30,389

actually use that to diagnose what's

806

00:35:28,710 --> 00:35:32,010

going on if we understand what the

807

00:35:30,389 --> 00:35:36,629

images are that went into the the

808

00:35:32,010 --> 00:35:38,280

pictures okay so one of the problems

809

00:35:36,630 --> 00:35:40,260

that we have just looking locally you

810

00:35:38,280 --> 00:35:42,390

say why don't we look at m83 look you

811

00:35:40,260 --> 00:35:44,190

know 15 million light years away in

812

00:35:42,389 --> 00:35:45,420

another galaxy to find supernovae in

813
00:35:44,190 --> 00:35:47,610
this we've got ones in our own galaxy

814
00:35:45,420 --> 00:35:50,430
that we can look at in great detail and

815
00:35:47,610 --> 00:35:52,769
indeed we do but part of the problem is

816
00:35:50,429 --> 00:35:55,469
that we have very few of these very

817
00:35:52,769 --> 00:35:57,090
young objects that we can look at and

818
00:35:55,469 --> 00:35:59,099
understand and kind of put together the

819
00:35:57,090 --> 00:36:00,990
big picture of what's going on this is

820
00:35:59,099 --> 00:36:02,699
the Crab Nebula with Hubble three

821
00:36:00,989 --> 00:36:05,219
different wavelengths of Hubble light

822
00:36:02,699 --> 00:36:07,529
put together into a couple color picture

823
00:36:05,219 --> 00:36:10,439
here and this is the Cassiopeia a

824
00:36:07,530 --> 00:36:13,170
supernova remnant which is a much more

825
00:36:10,440 --> 00:36:16,289
massive star that blew up in our galaxy

826
00:36:13,170 --> 00:36:17,909
and this is the same color coding that I

827

00:36:16,289 --> 00:36:20,039
had on that Kepler picture a minute ago

828
00:36:17,909 --> 00:36:22,829
where the yellow is a Hubble and the red

829
00:36:20,039 --> 00:36:24,809
is the infrared band and the blue and

830
00:36:22,829 --> 00:36:27,299
the green are the x-ray and you can see

831
00:36:24,809 --> 00:36:28,889
how they all mess up there and this in

832
00:36:27,300 --> 00:36:32,310
this explosion which is expanding at

833
00:36:28,889 --> 00:36:33,989
very high velocities even some 300 400

834
00:36:32,309 --> 00:36:35,759
years after the explosion still

835
00:36:33,989 --> 00:36:37,799
expanding at ten or twelve thousand

836
00:36:35,760 --> 00:36:41,220
kilometers per second interestingly

837
00:36:37,800 --> 00:36:41,460
enough the Crab Nebula almost a thousand

838
00:36:41,219 --> 00:36:44,039
years

839
00:36:41,460 --> 00:36:45,929
old and it's only expanding at 1,800

840
00:36:44,039 --> 00:36:48,960
kilometers per second and we think it

841
00:36:45,929 --> 00:36:51,719

came from a much lower mass star so

842

00:36:48,960 --> 00:36:53,338

let's say we have half a dozen of these

843

00:36:51,719 --> 00:36:55,259

kinds of objects or something like that

844

00:36:53,338 --> 00:36:58,588

to look at we've got the mass varying

845

00:36:55,260 --> 00:37:00,480

we've got the expansion the age is

846

00:36:58,588 --> 00:37:02,250

different the expansion velocities are

847

00:37:00,480 --> 00:37:03,809

different how do we take all these

848

00:37:02,250 --> 00:37:05,460

pieces of information and put it

849

00:37:03,809 --> 00:37:07,858

together into a picture when we have so

850

00:37:05,460 --> 00:37:10,858

few objects to kind of put together and

851

00:37:07,858 --> 00:37:14,369

make that picture and just as a another

852

00:37:10,858 --> 00:37:16,679

sign of how crazy these are this 8 or 10

853

00:37:14,369 --> 00:37:18,869

solar mass star we know produced this

854

00:37:16,679 --> 00:37:20,730

inquiry this crazy Crab Nebula pulsar

855

00:37:18,869 --> 00:37:22,230

down here in the center of the object

856
00:37:20,730 --> 00:37:24,510
that is actually what's energizing and

857
00:37:22,230 --> 00:37:27,599
actually accelerating the expansion of

858
00:37:24,510 --> 00:37:30,359
the material from the explosion whereas

859
00:37:27,599 --> 00:37:32,190
this big monster 25 solar mass star that

860
00:37:30,358 --> 00:37:33,929
blew up here made this wimpy little

861
00:37:32,190 --> 00:37:36,690
neutron star down here that we don't

862
00:37:33,929 --> 00:37:38,549
even see any pulses from there so there

863
00:37:36,690 --> 00:37:40,588
is a stellar remnant left behind from

864
00:37:38,550 --> 00:37:43,650
the explosion but it's not anything that

865
00:37:40,588 --> 00:37:47,190
would knock your socks off like the Crab

866
00:37:43,650 --> 00:37:51,000
Nebula pulsar so very few objects to

867
00:37:47,190 --> 00:37:53,460
understand the parameter space and many

868
00:37:51,000 --> 00:37:55,650
things changing it makes it hard and so

869
00:37:53,460 --> 00:37:57,358
we'd like to find a lot of these young

870
00:37:55,650 --> 00:37:58,619
remnants and look at them especially if

871
00:37:57,358 --> 00:38:00,449
they were all at the same distance you

872
00:37:58,619 --> 00:38:02,430
take the distance difference out of it

873
00:38:00,449 --> 00:38:03,659
you can look at that sample of objects

874
00:38:02,429 --> 00:38:06,989
that are all at the same distance and

875
00:38:03,659 --> 00:38:09,420
understand systematically what's going

876
00:38:06,989 --> 00:38:10,709
on with massive star supernova remnants

877
00:38:09,420 --> 00:38:15,930
so that was one of the motivations for

878
00:38:10,710 --> 00:38:17,550
going to how to m83 alright so I'm gonna

879
00:38:15,929 --> 00:38:18,690
leave the Crab Nebula behind now that

880
00:38:17,550 --> 00:38:20,369
was kind of at the lower end of a

881
00:38:18,690 --> 00:38:22,619
massive star these are all these are

882
00:38:20,369 --> 00:38:25,349
three supernova remnants of we think

883
00:38:22,619 --> 00:38:27,599
very massive stars here's Cassie again

884

00:38:25,349 --> 00:38:30,599
in our galaxy and below below here I

885
00:38:27,599 --> 00:38:33,059
just have a blow-up of some Hubble data

886
00:38:30,599 --> 00:38:36,030
that that shows some of the detail in

887
00:38:33,059 --> 00:38:38,130
this stuff this is star stuff this is

888
00:38:36,030 --> 00:38:40,560
the guts of the massive star that blew

889
00:38:38,130 --> 00:38:42,358
up and the material is still in the

890
00:38:40,559 --> 00:38:45,269
process of flying out into space at very

891
00:38:42,358 --> 00:38:46,829
high velocities and eventually it will

892
00:38:45,269 --> 00:38:49,170
blend back into the interstellar medium

893
00:38:46,829 --> 00:38:52,219
and maybe participate in the next round

894
00:38:49,170 --> 00:38:55,699
of star formation that will have

895
00:38:52,219 --> 00:38:57,858
abundances then the current ones do okay

896
00:38:55,699 --> 00:39:00,289
this is an object in a small magellanic

897
00:38:57,858 --> 00:39:03,170
cloud that is very similar to this only

898
00:39:00,289 --> 00:39:05,599

it's larger it's older but the only

899

00:39:03,170 --> 00:39:07,909

thing we see with Hubble this blue stuff

900

00:39:05,599 --> 00:39:09,318

that you see in that picture is almost

901

00:39:07,909 --> 00:39:11,538

pure oxygen

902

00:39:09,318 --> 00:39:14,119

it's from the layer of the star that

903

00:39:11,539 --> 00:39:15,259

produced oxygen there if you took a

904

00:39:14,119 --> 00:39:16,759

spectrum of that you would see there

905

00:39:15,259 --> 00:39:19,458

would be some neon and some other things

906

00:39:16,759 --> 00:39:22,159

in there but as you see no hydrogen it's

907

00:39:19,458 --> 00:39:24,978

all the star stuff that's flying out

908

00:39:22,159 --> 00:39:26,989

into space this object is in the Large

909

00:39:24,978 --> 00:39:31,818

Magellanic Cloud or neighboring galaxies

910

00:39:26,989 --> 00:39:33,528

of ours and it is larger it has a kind

911

00:39:31,818 --> 00:39:35,239

of an outer shell here that's starting

912

00:39:33,528 --> 00:39:36,528

to form from the blast wave going out of

913
00:39:35,239 --> 00:39:38,449
the space and starting to sweep up

914
00:39:36,528 --> 00:39:40,818
surrounding material so you're getting

915
00:39:38,449 --> 00:39:43,369
that outer shell starting to form but

916
00:39:40,818 --> 00:39:46,429
down in the center here this blue and

917
00:39:43,369 --> 00:39:47,930
green stuff in this picture is this kind

918
00:39:46,429 --> 00:39:50,509
of stuff it's the star stuff still

919
00:39:47,929 --> 00:39:53,899
visible even though it's a much much

920
00:39:50,509 --> 00:39:55,998
older object and to put those three in a

921
00:39:53,900 --> 00:39:58,338
little more of a context for you and in

922
00:39:55,998 --> 00:40:01,488
this graph I try to graphic I try to

923
00:39:58,338 --> 00:40:05,119
show you their relative sizes to give

924
00:40:01,489 --> 00:40:07,249
you a little sense so Cassie 340 years

925
00:40:05,119 --> 00:40:10,278
since the explosion 18 light-years in

926
00:40:07,248 --> 00:40:13,608
size yellow 102 this one with the

927
00:40:10,278 --> 00:40:15,978
phonebook name is about 1200 years old

928
00:40:13,608 --> 00:40:18,348
and is a little over 40 kilometres per

929
00:40:15,978 --> 00:40:21,018
second this is expanding at say 10,000

930
00:40:18,349 --> 00:40:22,969
this is 2,000 and over here the outer

931
00:40:21,018 --> 00:40:25,488
structure is not expanding rapidly but

932
00:40:22,969 --> 00:40:27,829
that green stuff the oxygen stuff in

933
00:40:25,489 --> 00:40:30,619
there is still expanding and a thousand

934
00:40:27,829 --> 00:40:33,890
kilometers per second even some 3,000

935
00:40:30,619 --> 00:40:35,749
years or more after the explosion and so

936
00:40:33,889 --> 00:40:37,969
if we wanted to find this kind of object

937
00:40:35,748 --> 00:40:39,919
in other galaxies we would want to look

938
00:40:37,969 --> 00:40:41,869
for high velocities and we would want to

939
00:40:39,920 --> 00:40:44,719
look for these funny abundances compared

940
00:40:41,869 --> 00:40:47,599
to the surrounding gas and that's one of

941

00:40:44,719 --> 00:40:49,309
the ways we try to find them I'm just

942
00:40:47,599 --> 00:40:52,489
taking that one step further I like to

943
00:40:49,309 --> 00:40:54,259
make this point because you know this is

944
00:40:52,489 --> 00:40:56,119
thought of as a young object the veil

945
00:40:54,259 --> 00:40:57,559
nebula the Cygnus loop is thought of

946
00:40:56,119 --> 00:40:59,088
it's kind of an old or a middle-aged

947
00:40:57,559 --> 00:41:01,429
object and yet sighs this is the

948
00:40:59,088 --> 00:41:03,969
relative sizes again not too different

949
00:41:01,429 --> 00:41:05,240
88 light years versus 82 light years

950
00:41:03,969 --> 00:41:07,639
inside

951
00:41:05,239 --> 00:41:09,979
again this outer shell is thought to be

952
00:41:07,639 --> 00:41:12,440
sort of the wall of a cavity that was

953
00:41:09,980 --> 00:41:14,809
blown by the wind from the star before

954
00:41:12,440 --> 00:41:17,090
it blew up so there's a cavity that it's

955
00:41:14,809 --> 00:41:18,469

expanding into that's the same model we

956

00:41:17,090 --> 00:41:20,360

have for the Cygnus loop this bright

957

00:41:18,469 --> 00:41:21,799

emission on the outside edges where the

958

00:41:20,360 --> 00:41:24,829

shock wave is finally starting to hit

959

00:41:21,800 --> 00:41:26,240

the outside edges of a cavity so the two

960

00:41:24,829 --> 00:41:28,069

stars the blue up here could be very

961

00:41:26,239 --> 00:41:31,369

similar to each other and yet we don't

962

00:41:28,070 --> 00:41:33,530

see the oxygen-rich the ejecta in this

963

00:41:31,369 --> 00:41:35,389

one they're starting to tease it out of

964

00:41:33,530 --> 00:41:36,650

very deep x-ray observations in the

965

00:41:35,389 --> 00:41:38,329

Cygnus oh they're starting to see some

966

00:41:36,650 --> 00:41:40,700

of that enhancement but most of that

967

00:41:38,329 --> 00:41:43,579

stuff is blended back in or faded away

968

00:41:40,699 --> 00:41:45,259

at this point and so this object is on

969

00:41:43,579 --> 00:41:46,460

its way to becoming something like the

970
00:41:45,260 --> 00:41:50,120
Cygnus of when they're about the same

971
00:41:46,460 --> 00:41:51,349
the same size this has nothing to do

972
00:41:50,119 --> 00:41:52,460
with the rest of the talk but I had to

973
00:41:51,349 --> 00:41:55,219
throw it in here you see this little

974
00:41:52,460 --> 00:41:57,079
white box on the side there was this

975
00:41:55,219 --> 00:41:59,269
wonderful picture of the Cygnus loop

976
00:41:57,079 --> 00:42:02,150
just that tiny little section that was

977
00:41:59,269 --> 00:42:03,949
released last year that makes the point

978
00:42:02,150 --> 00:42:05,480
also that you know you use the different

979
00:42:03,949 --> 00:42:08,269
colors to represent things so we've got

980
00:42:05,480 --> 00:42:11,269
an oxygen hydrogen and a sulphur band in

981
00:42:08,269 --> 00:42:12,650
blue red and green and then you can see

982
00:42:11,269 --> 00:42:15,590
how the colors are mixing together you

983
00:42:12,650 --> 00:42:17,660
get the yellows which means that H alpha

984
00:42:15,590 --> 00:42:19,160
and the software too are bright you see

985
00:42:17,659 --> 00:42:21,559
the places where the blue is dominant

986
00:42:19,159 --> 00:42:23,029
where the oxygen high ionization oxygen

987
00:42:21,559 --> 00:42:24,949
is dominant and so forth so you can

988
00:42:23,030 --> 00:42:28,269
again you get a sense for what how you

989
00:42:24,949 --> 00:42:30,589
get diagnostic power out of the color

990
00:42:28,269 --> 00:42:32,989
images if you understand something about

991
00:42:30,590 --> 00:42:35,630
what's going into the picture but that's

992
00:42:32,989 --> 00:42:38,269
just a spectacular picture this cloud up

993
00:42:35,630 --> 00:42:39,619
here is probably unrelated directly to

994
00:42:38,269 --> 00:42:41,119
this it's either the foreground or

995
00:42:39,619 --> 00:42:43,130
background and just happens to be in the

996
00:42:41,119 --> 00:42:46,549
frame out here and there's a one light

997
00:42:43,130 --> 00:42:48,260
one light-year bar across there so so

998

00:42:46,550 --> 00:42:50,180
the whole object of course is much much

999
00:42:48,260 --> 00:42:52,250
much much larger we're looking at a tiny

1000
00:42:50,179 --> 00:42:57,529
little piece of it and this this Hubble

1001
00:42:52,250 --> 00:43:00,440
picture this picture is 18 orbits of

1002
00:42:57,530 --> 00:43:02,210
Hubble data about a hundred separate

1003
00:43:00,440 --> 00:43:03,980
images and those different filters all

1004
00:43:02,210 --> 00:43:06,909
align then put together this was

1005
00:43:03,980 --> 00:43:09,590
actually three by two

1006
00:43:06,909 --> 00:43:11,179
wipsy three fields of view for the

1007
00:43:09,590 --> 00:43:13,730
Hubble telescope so this has been all

1008
00:43:11,179 --> 00:43:15,379
stitched together four six six fields of

1009
00:43:13,730 --> 00:43:17,250
the of the wide field camera to put

1010
00:43:15,380 --> 00:43:20,130
together this picture of that one

1011
00:43:17,250 --> 00:43:22,739
piece of the cygnets loop Hubble's job

1012
00:43:20,130 --> 00:43:24,930

is to look at small areas of the sky in

1013

00:43:22,739 --> 00:43:29,309

very great detail that's that's this

1014

00:43:24,929 --> 00:43:31,500

reason for existence basically okay well

1015

00:43:29,309 --> 00:43:33,059

we're almost to m83 I just want to kind

1016

00:43:31,500 --> 00:43:34,860

of give you the big picture here first I

1017

00:43:33,059 --> 00:43:37,559

mean the idea remember is that we want

1018

00:43:34,860 --> 00:43:40,019

to understand the star formation

1019

00:43:37,559 --> 00:43:42,509

processes and the whole evolution of

1020

00:43:40,019 --> 00:43:44,849

stars and we want to do that for the

1021

00:43:42,510 --> 00:43:47,100

four galaxies in the local universe it

1022

00:43:44,849 --> 00:43:48,960

turns out m83 is a prime testing ground

1023

00:43:47,099 --> 00:43:51,150

for doing this because you want to

1024

00:43:48,960 --> 00:43:52,889

understand by comparing local galaxies

1025

00:43:51,150 --> 00:43:55,230

to more distant galaxies whether these

1026

00:43:52,889 --> 00:43:57,269

processes that that that guide this

1027
00:43:55,230 --> 00:44:00,179
stuff are universal processes or whether

1028
00:43:57,269 --> 00:44:01,800
there are differences and the part that

1029
00:44:00,179 --> 00:44:03,719
I'm really most interested in most

1030
00:44:01,800 --> 00:44:05,430
involved in is in finding the supernova

1031
00:44:03,719 --> 00:44:09,509
remnants which is just the one part of

1032
00:44:05,429 --> 00:44:10,409
this bigger picture so most of the rest

1033
00:44:09,510 --> 00:44:12,000
of this I'm going to be talking about

1034
00:44:10,409 --> 00:44:13,920
trying to find the supernova remnants

1035
00:44:12,000 --> 00:44:15,360
and telling you how we do that so here's

1036
00:44:13,920 --> 00:44:18,210
a ground-based picture very nice

1037
00:44:15,360 --> 00:44:20,400
ground-based picture of m83 about 15

1038
00:44:18,210 --> 00:44:22,679
million light years away one arcsecond

1039
00:44:20,400 --> 00:44:24,840
is about 72 light years and one

1040
00:44:22,679 --> 00:44:26,309
arcsecond is kind of as you a lot of

1041
00:44:24,840 --> 00:44:27,960
amateur astronomers out here I presume

1042
00:44:26,309 --> 00:44:29,579
were people that know that's basically

1043
00:44:27,960 --> 00:44:31,440
kind of what you get from ground-based

1044
00:44:29,579 --> 00:44:33,269
observations is about one arc second or

1045
00:44:31,440 --> 00:44:35,010
sometimes a little bit worse sometimes a

1046
00:44:33,269 --> 00:44:36,570
little bit better but of course Hubble

1047
00:44:35,010 --> 00:44:38,100
can do about twenty times better than

1048
00:44:36,570 --> 00:44:40,500
that so we're getting down to just a few

1049
00:44:38,099 --> 00:44:42,269
light years type resolution with Hubble

1050
00:44:40,500 --> 00:44:44,489
pictures when we look at this thing

1051
00:44:42,269 --> 00:44:46,259
that's 15 million light years away and

1052
00:44:44,489 --> 00:44:48,209
we can still resolve things that's just

1053
00:44:46,260 --> 00:44:51,420
a few light-years in size that's pretty

1054
00:44:48,210 --> 00:44:53,039
spectacular okay it's a called a barred

1055

00:44:51,420 --> 00:44:54,659
spiral galaxy there's certainly other

1056
00:44:53,039 --> 00:44:56,159
galaxies and have more prominent bars

1057
00:44:54,659 --> 00:44:58,230
but you can see it's kind of extended

1058
00:44:56,159 --> 00:45:01,139
here it's got this very bright nucleus

1059
00:44:58,230 --> 00:45:04,019
where star formation is just happening

1060
00:45:01,139 --> 00:45:06,239
at a tremendous burst but you see also a

1061
00:45:04,019 --> 00:45:08,219
lot of these h2 regions around out

1062
00:45:06,239 --> 00:45:10,829
through the spiral arms where where star

1063
00:45:08,219 --> 00:45:12,119
formation is happening it turns out this

1064
00:45:10,829 --> 00:45:14,130
galaxy is a great place to look for

1065
00:45:12,119 --> 00:45:17,190
supernova remnants because it's produced

1066
00:45:14,130 --> 00:45:19,440
a ton of supernovae we've actually seen

1067
00:45:17,190 --> 00:45:22,400
over the last hundred years six

1068
00:45:19,440 --> 00:45:25,110
supernovae in m83

1069
00:45:22,400 --> 00:45:27,720

we found another object that I'll

1070

00:45:25,110 --> 00:45:29,309

mention briefly as we go along that has

1071

00:45:27,719 --> 00:45:30,598

to be less than 100 years old that was

1072

00:45:29,309 --> 00:45:33,268

probably a supernova that

1073

00:45:30,599 --> 00:45:35,068

did not see maybe it happened when

1074

00:45:33,268 --> 00:45:36,899

anybody through is behind the Sun we

1075

00:45:35,068 --> 00:45:38,278

don't know exactly but anyway there's

1076

00:45:36,900 --> 00:45:39,568

another one that's young that's so

1077

00:45:38,278 --> 00:45:42,929

probably seven of them in the last

1078

00:45:39,568 --> 00:45:47,579

century interestingly enough none since

1079

00:45:42,929 --> 00:45:49,469

1983 we are do we are do we had seven of

1080

00:45:47,579 --> 00:45:51,150

them in the first part of the 20th

1081

00:45:49,469 --> 00:45:52,889

century and now none since thinking 83

1082

00:45:51,150 --> 00:45:55,338

so we ought to be seeing some super

1083

00:45:52,889 --> 00:45:57,719

novae coming for maybe three pretty soon

1084
00:45:55,338 --> 00:45:59,518
and just for context again this is a

1085
00:45:57,719 --> 00:46:00,988
quarter of a degree field of view that I

1086
00:45:59,518 --> 00:46:02,548
was showing here of course the full moon

1087
00:46:00,989 --> 00:46:05,999
is about a half a degree across so it's

1088
00:46:02,548 --> 00:46:07,288
a sizable galaxy on the sky but

1089
00:46:05,998 --> 00:46:09,449
interestingly enough if you put this

1090
00:46:07,289 --> 00:46:11,400
where the Milky Way is this this whole

1091
00:46:09,449 --> 00:46:13,228
thing is you would like put two

1092
00:46:11,400 --> 00:46:14,670
side-by-side and two up and down that's

1093
00:46:13,228 --> 00:46:16,409
gonna be about the size of the Milky Way

1094
00:46:14,670 --> 00:46:18,869
galaxy so it's actually a relatively

1095
00:46:16,409 --> 00:46:19,588
small spiral galaxy compared to our

1096
00:46:18,869 --> 00:46:24,630
Milky Way

1097
00:46:19,588 --> 00:46:26,130
I mentioned that it had six or possibly

1098
00:46:24,630 --> 00:46:28,829
seven supernovae here's where they are

1099
00:46:26,130 --> 00:46:30,358
located across the galaxy some of them

1100
00:46:28,829 --> 00:46:33,450
are very close to star forming regions

1101
00:46:30,358 --> 00:46:35,400
some of them are are not one is right

1102
00:46:33,449 --> 00:46:36,899
down here in the in this bright nucleus

1103
00:46:35,400 --> 00:46:40,259
where there's tremendous activity going

1104
00:46:36,900 --> 00:46:41,910
on near star formation again your star

1105
00:46:40,259 --> 00:46:43,949
formation up here I'll talk about this

1106
00:46:41,909 --> 00:46:45,778
object and this object this is the one

1107
00:46:43,949 --> 00:46:48,568
that I think we found that has to be

1108
00:46:45,778 --> 00:46:50,960
young but the supernova was not seen but

1109
00:46:48,568 --> 00:46:53,818
the point is with this many supernovae

1110
00:46:50,960 --> 00:46:55,380
less than a hundred years old if we want

1111
00:46:53,818 --> 00:46:58,108
to take what you want to take a thousand

1112

00:46:55,380 --> 00:47:00,150
or 1500 years as a young supernova

1113
00:46:58,108 --> 00:47:03,179
remnant there ought to be 6070 maybe

1114
00:47:00,150 --> 00:47:05,519
even a hundred of these young ejecta

1115
00:47:03,179 --> 00:47:07,288
dominated supernova remnants in this

1116
00:47:05,518 --> 00:47:08,939
galaxy and so that's why one of the

1117
00:47:07,289 --> 00:47:10,289
reasons we wanted to look here we also

1118
00:47:08,940 --> 00:47:12,778
wanted to find the normal supernova

1119
00:47:10,289 --> 00:47:14,789
remnants like the Cygnus loop and so the

1120
00:47:12,778 --> 00:47:18,059
search actually looked for both of those

1121
00:47:14,789 --> 00:47:20,069
things so just very briefly we used a

1122
00:47:18,059 --> 00:47:22,528
large ground-based telescope here at Las

1123
00:47:20,068 --> 00:47:25,308
Campanas Observatory for a ground-based

1124
00:47:22,528 --> 00:47:28,170
search and we actually found 225

1125
00:47:25,309 --> 00:47:30,329
supernova remnant candidates from that

1126
00:47:28,170 --> 00:47:32,338

ground-based search so the question is

1127

00:47:30,329 --> 00:47:33,839

why do we need Hubble well we could find

1128

00:47:32,338 --> 00:47:35,969

them but we couldn't measure their sizes

1129

00:47:33,838 --> 00:47:38,518

from the ground even with very excellent

1130

00:47:35,969 --> 00:47:40,200

ground-based data most of the objects we

1131

00:47:38,518 --> 00:47:41,879

wanted to get you know see if they had

1132

00:47:40,199 --> 00:47:44,309

shells or if they were very small

1133

00:47:41,880 --> 00:47:46,019

objects or whatever we couldn't do with

1134

00:47:44,309 --> 00:47:47,759

with Magellan and so we had to do that

1135

00:47:46,019 --> 00:47:50,570

with with Hubble and so down here is the

1136

00:47:47,760 --> 00:47:53,040

Hubble part of the project we also have

1137

00:47:50,570 --> 00:47:55,650

730 Killa seconds that's a lot of time

1138

00:47:53,039 --> 00:47:57,360

on the Chandra x-ray Observatory to take

1139

00:47:55,650 --> 00:47:59,519

a very deep x-ray picture of this galaxy

1140

00:47:57,360 --> 00:48:01,559

we found four hundred and forty point

1141
00:47:59,519 --> 00:48:03,000
sources and lots of the few submission

1142
00:48:01,559 --> 00:48:04,230
I'll show you that and then there are

1143
00:48:03,000 --> 00:48:06,469
other datasets that we're working on

1144
00:48:04,230 --> 00:48:08,639
including radio again multi-wavelength

1145
00:48:06,469 --> 00:48:11,339
spectroscopic follow up and I'll show

1146
00:48:08,639 --> 00:48:13,409
you a couple of spectra from that as we

1147
00:48:11,340 --> 00:48:17,250
go along but I basically won't talk

1148
00:48:13,409 --> 00:48:20,759
about those very much that part of it so

1149
00:48:17,250 --> 00:48:24,360
there is I showed you here the optical

1150
00:48:20,760 --> 00:48:26,880
picture of the galaxy right and here is

1151
00:48:24,360 --> 00:48:28,769
this deep x-ray picture of the galaxy -

1152
00:48:26,880 --> 00:48:30,390
approximately the same scale you can

1153
00:48:28,769 --> 00:48:32,789
even kind of see the spiral arms and

1154
00:48:30,389 --> 00:48:36,469
that red diffuse gas there you see this

1155
00:48:32,789 --> 00:48:40,139
incredible x-ray bright region

1156
00:48:36,469 --> 00:48:42,449
associated with the starburst nucleus in

1157
00:48:40,139 --> 00:48:44,549
there and all these little point sources

1158
00:48:42,449 --> 00:48:46,769
and vast majority of those point sources

1159
00:48:44,550 --> 00:48:49,320
are actually in n83 a lot of the

1160
00:48:46,769 --> 00:48:52,230
brighter whitish looking ones are x-ray

1161
00:48:49,320 --> 00:48:53,850
binary stars and you can see that

1162
00:48:52,230 --> 00:48:55,139
because some of those sources vary over

1163
00:48:53,849 --> 00:48:57,360
time and whatnot because they're in

1164
00:48:55,139 --> 00:48:58,650
binary orbits and the things that don't

1165
00:48:57,360 --> 00:49:00,900
look too impressive on here a lot of

1166
00:48:58,650 --> 00:49:03,150
these little little red red dots or

1167
00:49:00,900 --> 00:49:05,460
yellow dots and places are oftentimes

1168
00:49:03,150 --> 00:49:07,289
are associated with optical supernova

1169

00:49:05,460 --> 00:49:09,329
remnants so we have a lot of supernovae

1170
00:49:07,289 --> 00:49:11,909
that show up the color coding here goes

1171
00:49:09,329 --> 00:49:14,009
from relatively low energy x-rays in the

1172
00:49:11,909 --> 00:49:16,529
red up to the higher and their energy

1173
00:49:14,010 --> 00:49:18,960
x-rays in the blue and so this diffuse

1174
00:49:16,530 --> 00:49:21,000
gas this is the brightest diffuse x-ray

1175
00:49:18,960 --> 00:49:23,280
emission that we have seen in any spiral

1176
00:49:21,000 --> 00:49:24,449
galaxy by the way so if it doesn't look

1177
00:49:23,280 --> 00:49:26,370
too impressive to you you should see

1178
00:49:24,449 --> 00:49:27,119
some of the other galaxies this looks

1179
00:49:26,369 --> 00:49:29,880
pretty good

1180
00:49:27,119 --> 00:49:33,089
and just that tells us that there is hot

1181
00:49:29,880 --> 00:49:35,280
low-density gas permeating the spiral

1182
00:49:33,090 --> 00:49:38,280
arms of this galaxy and that has been

1183
00:49:35,280 --> 00:49:40,590

energized by the stellar formation the

1184

00:49:38,280 --> 00:49:43,320

winds from the stars and the supernova

1185

00:49:40,590 --> 00:49:45,450

explosions over time have energized the

1186

00:49:43,320 --> 00:49:48,559

interstellar medium of this galaxy and

1187

00:49:45,449 --> 00:49:53,069

we get this incredible bright diffuse

1188

00:49:48,559 --> 00:49:54,900

emission also just a little blow-up and

1189

00:49:53,070 --> 00:49:56,880

rescaled so that it's not burned out

1190

00:49:54,900 --> 00:49:57,420

this nuclear region has a tremendous

1191

00:49:56,880 --> 00:50:00,240

number of

1192

00:49:57,420 --> 00:50:01,769

sources and the few submission in there

1193

00:50:00,239 --> 00:50:03,750

as well it's a very complicated reason

1194

00:50:01,769 --> 00:50:05,099

some of those again are aligned with

1195

00:50:03,750 --> 00:50:07,048

supernova remnants and other ones that

1196

00:50:05,099 --> 00:50:09,059

are x-ray binaries in that very active

1197

00:50:07,048 --> 00:50:11,400

nucleus but it's so confused in there

1198
00:50:09,059 --> 00:50:17,130
we've mostly set that aside and worked

1199
00:50:11,400 --> 00:50:19,889
on the outer part of the galaxy the big

1200
00:50:17,130 --> 00:50:21,329
picture here is that m83 although it's

1201
00:50:19,889 --> 00:50:23,159
hanging out there looks like a nice big

1202
00:50:21,329 --> 00:50:26,430
bright spiral galaxy all by itself is

1203
00:50:23,159 --> 00:50:28,199
actually much more extended than we give

1204
00:50:26,429 --> 00:50:29,730
it credit for this is the part we've

1205
00:50:28,199 --> 00:50:32,368
been looking at here in the bright part

1206
00:50:29,730 --> 00:50:34,548
this is galaxies ultraviolet images and

1207
00:50:32,369 --> 00:50:37,349
the red and this picture is actually

1208
00:50:34,548 --> 00:50:39,539
radio h1 emission hydrogen emission that

1209
00:50:37,349 --> 00:50:43,140
shows that there is very faint diffuse

1210
00:50:39,539 --> 00:50:44,849
gas way out there and the blue light

1211
00:50:43,139 --> 00:50:46,650
that you see way out here is star

1212
00:50:44,849 --> 00:50:48,869
formation that is actually happening way

1213
00:50:46,650 --> 00:50:49,500
out here away from the bright part of

1214
00:50:48,869 --> 00:50:51,750
the galaxy

1215
00:50:49,500 --> 00:50:53,338
this probably indicates that at some

1216
00:50:51,750 --> 00:50:55,170
point in the not-too-distant past and

1217
00:50:53,338 --> 00:50:57,269
maybe three had an interaction with

1218
00:50:55,170 --> 00:50:58,920
another galaxy and we don't see that

1219
00:50:57,269 --> 00:51:00,869
other galaxy right now but it was enough

1220
00:50:58,920 --> 00:51:03,000
to kind of really disturb the outer

1221
00:51:00,869 --> 00:51:04,920
structure of m83

1222
00:51:03,000 --> 00:51:08,298
and maybe what triggered this big burst

1223
00:51:04,920 --> 00:51:10,619
of star formation in the galaxy itself

1224
00:51:08,298 --> 00:51:14,909
so that's a much larger scale picture

1225
00:51:10,619 --> 00:51:16,559
than what we were looking at before okay

1226

00:51:14,909 --> 00:51:19,769
so how do we find supernova remnants

1227
00:51:16,559 --> 00:51:22,410
these are spectrum aren't they beautiful

1228
00:51:19,769 --> 00:51:25,139
people like rainbows for spectra for an

1229
00:51:22,409 --> 00:51:27,719
astronomer a graph of intensity versus

1230
00:51:25,139 --> 00:51:29,400
wavelength or versus color blue to red

1231
00:51:27,719 --> 00:51:30,929
in this case these are optical spectra

1232
00:51:29,400 --> 00:51:33,298
intensity

1233
00:51:30,929 --> 00:51:35,399
these are Specter to an astronomer and

1234
00:51:33,298 --> 00:51:36,900
what you see here you see some low-level

1235
00:51:35,400 --> 00:51:38,910
noise going across everything you see

1236
00:51:36,900 --> 00:51:40,440
these spikes that go up this is called

1237
00:51:38,909 --> 00:51:43,379
an emission line spectrum if you look at

1238
00:51:40,440 --> 00:51:45,329
a gas cloud on h2 region or a supernova

1239
00:51:43,380 --> 00:51:48,329
remnant you see emission lines these

1240
00:51:45,329 --> 00:51:49,890

spikes in the spectrum okay and despite

1241

00:51:48,329 --> 00:51:51,660

the relative intensities of the spikes

1242

00:51:49,889 --> 00:51:53,578

change as you look at different objects

1243

00:51:51,659 --> 00:51:57,179

as you look at different kinds of

1244

00:51:53,579 --> 00:51:59,970

objects okay so this is a shock heated

1245

00:51:57,179 --> 00:52:01,558

supernova remnant and what you see is

1246

00:51:59,969 --> 00:52:04,709

that this little line of sulphur out

1247

00:52:01,559 --> 00:52:06,180

here is much stronger relative to the

1248

00:52:04,710 --> 00:52:09,030

hydrogen and there's actually nitrogen

1249

00:52:06,179 --> 00:52:11,190

lines here right next to it the software

1250

00:52:09,030 --> 00:52:15,329

to jumps up the self-reliance jump

1251

00:52:11,190 --> 00:52:17,159

way up the oxygen lines in m83 get very

1252

00:52:15,329 --> 00:52:20,099

strong and many supernovae retinas not

1253

00:52:17,159 --> 00:52:22,858

all of them whereas in the photo star

1254

00:52:20,099 --> 00:52:26,730

light ionized gas the oxygen is very

1255
00:52:22,858 --> 00:52:28,650
weak the sulfur is very weak so knowing

1256
00:52:26,730 --> 00:52:30,599
what the spectra look like now I want to

1257
00:52:28,650 --> 00:52:32,849
say let's go and take pictures and we're

1258
00:52:30,599 --> 00:52:36,690
going to take little filters that just

1259
00:52:32,849 --> 00:52:37,769
get the light from pieces of the

1260
00:52:36,690 --> 00:52:39,119
spectrum and we're going to take

1261
00:52:37,769 --> 00:52:43,259
pictures and then we're going to do an

1262
00:52:39,119 --> 00:52:44,970
RGB of these filters and look for color

1263
00:52:43,260 --> 00:52:48,810
combinations that will tell us which

1264
00:52:44,969 --> 00:52:49,919
objects have strong sulfur - okay and

1265
00:52:48,809 --> 00:52:52,769
that's how we find the supernova

1266
00:52:49,920 --> 00:52:54,650
remnants for the ejecta dominated guys

1267
00:52:52,769 --> 00:52:56,909
it's a little bit different this is a

1268
00:52:54,650 --> 00:52:59,730
spectrum and integrative spectrum of

1269
00:52:56,909 --> 00:53:01,949
Caffe in our galaxy first thing you

1270
00:52:59,730 --> 00:53:03,900
notice of course is the lines are huge

1271
00:53:01,949 --> 00:53:08,368
broad lines that's from that high

1272
00:53:03,900 --> 00:53:10,588
velocity of the ejecta still moving they

1273
00:53:08,369 --> 00:53:11,970
aren't all that broad but but they don't

1274
00:53:10,588 --> 00:53:13,949
have to be that broad for us to see it

1275
00:53:11,969 --> 00:53:15,568
they just have to be broader than then

1276
00:53:13,949 --> 00:53:16,799
we see in these kind of spectra so if

1277
00:53:15,568 --> 00:53:19,559
you saw these things broadened you would

1278
00:53:16,800 --> 00:53:21,420
know that you get high velocity okay I

1279
00:53:19,559 --> 00:53:23,818
say okay so here's my oxygen filter

1280
00:53:21,420 --> 00:53:26,670
here's my H alpha filter there's almost

1281
00:53:23,818 --> 00:53:28,380
no H alpha and the sum of what's there

1282
00:53:26,670 --> 00:53:30,900
is not really related to the KSA and

1283

00:53:28,380 --> 00:53:33,059
then there's a sulphur - filter here so

1284
00:53:30,900 --> 00:53:35,338
this object would look bright and oxygen

1285
00:53:33,059 --> 00:53:38,009
bright and sulfur and almost no H alpha

1286
00:53:35,338 --> 00:53:39,599
or some of the oxygen rich reminisce

1287
00:53:38,010 --> 00:53:42,510
don't have sulphur either so that would

1288
00:53:39,599 --> 00:53:44,190
be right here and not much in either of

1289
00:53:42,510 --> 00:53:46,410
those two bands and so if I found things

1290
00:53:44,190 --> 00:53:48,809
like color coded this blue let's say

1291
00:53:46,409 --> 00:53:52,230
then things that look really blue ought

1292
00:53:48,809 --> 00:53:54,420
to be dominated by the do three emission

1293
00:53:52,230 --> 00:53:58,920
so that's how we find the ejected

1294
00:53:54,420 --> 00:54:01,139
dominated guys where we try to we can

1295
00:53:58,920 --> 00:54:04,318
get confused with just the optical data

1296
00:54:01,139 --> 00:54:07,500
here because planetary nebulae from low

1297
00:54:04,318 --> 00:54:10,108

mass stars also can have strong oxygen 3

1298

00:54:07,500 --> 00:54:13,608

and so the other thing we need is like

1299

00:54:10,108 --> 00:54:16,500

cafe we know we have this really strong

1300

00:54:13,608 --> 00:54:18,509

soft x-ray emission as well so we need

1301

00:54:16,500 --> 00:54:21,088

to see something that's bright and

1302

00:54:18,510 --> 00:54:22,210

oxygen and has an Associated x-ray

1303

00:54:21,088 --> 00:54:23,829

source and number

1304

00:54:22,210 --> 00:54:25,420

sure that we've got and ejected

1305

00:54:23,829 --> 00:54:30,009

dominated remnant otherwise it may just

1306

00:54:25,420 --> 00:54:30,460

be a planetary nebula so here's the

1307

00:54:30,010 --> 00:54:33,520

trick

1308

00:54:30,460 --> 00:54:35,858

all right we've h-alpha in red we put

1309

00:54:33,519 --> 00:54:38,559

oxygen three in blue and we put the

1310

00:54:35,858 --> 00:54:40,179

sulfur two in green now the sulfur to

1311

00:54:38,559 --> 00:54:42,130

line is actually in the red part of the

1312
00:54:40,179 --> 00:54:44,049
spectrum but if I did red red and blue

1313
00:54:42,130 --> 00:54:46,088
that I don't have any diagnostic power

1314
00:54:44,050 --> 00:54:48,490
right so I've made the sulfur to green

1315
00:54:46,088 --> 00:54:50,799
and now things that are yellow are

1316
00:54:48,489 --> 00:54:52,569
strong in sulfur Q and H alpha those are

1317
00:54:50,800 --> 00:54:56,230
the normal remnants if I find things

1318
00:54:52,570 --> 00:54:57,519
that are blue or in the cyan I'm pretty

1319
00:54:56,230 --> 00:54:59,440
sure that I've got something that might

1320
00:54:57,519 --> 00:55:02,858
be the ejecta dominated thing and that's

1321
00:54:59,440 --> 00:55:04,119
that's the trick that we play and so

1322
00:55:02,858 --> 00:55:06,029
here's a little example and I'm showing

1323
00:55:04,119 --> 00:55:08,019
you the black and white images

1324
00:55:06,030 --> 00:55:09,609
individually first and then here's the

1325
00:55:08,019 --> 00:55:12,429
color image down here that I'll get to

1326
00:55:09,608 --> 00:55:14,619
in a second so the trick also is that

1327
00:55:12,429 --> 00:55:16,509
when we take images in these emission

1328
00:55:14,619 --> 00:55:18,640
line filters you also get some Starlight

1329
00:55:16,510 --> 00:55:20,950
and so you take a picture that just look

1330
00:55:18,639 --> 00:55:23,259
gets the stars and you scale that and

1331
00:55:20,949 --> 00:55:25,659
subtract it away so you get a pure

1332
00:55:23,260 --> 00:55:27,099
emission line image so here except for

1333
00:55:25,659 --> 00:55:29,259
maybe a few little stellar residuals

1334
00:55:27,099 --> 00:55:31,960
like this you know this is the oxygen 3

1335
00:55:29,260 --> 00:55:34,420
emission only here's the H alpha

1336
00:55:31,960 --> 00:55:37,030
emission only and here's the sulphur 2

1337
00:55:34,420 --> 00:55:38,829
and you can do ratios in black and white

1338
00:55:37,030 --> 00:55:40,960
and actually you can find things right

1339
00:55:38,829 --> 00:55:42,670
like here's the the ratio of software to

1340

00:55:40,960 --> 00:55:45,338
2 H alpha and there's kind of three

1341
00:55:42,670 --> 00:55:47,349
three regions that pop out here and it

1342
00:55:45,338 --> 00:55:50,349
turns out here they are in sulfur 2

1343
00:55:47,349 --> 00:55:51,730
there they are NH alpha this was pretty

1344
00:55:50,349 --> 00:55:53,140
confused but these two you can see

1345
00:55:51,730 --> 00:55:55,240
they're about the same brightness and

1346
00:55:53,139 --> 00:55:57,519
sulfur 2 and H alpha is sure enough they

1347
00:55:55,239 --> 00:55:59,079
pop out in the ratio what's really neat

1348
00:55:57,519 --> 00:56:02,440
here is that even though there's all

1349
00:55:59,079 --> 00:56:04,598
this photo ionized gas around the region

1350
00:56:02,440 --> 00:56:06,420
you can still pull out in the ratio that

1351
00:56:04,599 --> 00:56:09,640
there's actually something with enhanced

1352
00:56:06,420 --> 00:56:11,530
ratio buried in that h2 region so

1353
00:56:09,639 --> 00:56:14,858
there's three supernova remnants right

1354
00:56:11,530 --> 00:56:16,780

there for you can look at the O 3 and

1355

00:56:14,858 --> 00:56:18,819

here's the yeah these two actually

1356

00:56:16,780 --> 00:56:21,160

happen to be fairly strong in oxygen 3

1357

00:56:18,820 --> 00:56:22,930

as well compared to H alpha and so let's

1358

00:56:21,159 --> 00:56:24,009

look at the color picture the ones that

1359

00:56:22,929 --> 00:56:25,779

are bright in all three are kind of

1360

00:56:24,010 --> 00:56:27,150

whitish or even a little bluish because

1361

00:56:25,780 --> 00:56:29,410

they've got so much of that oxygen

1362

00:56:27,150 --> 00:56:31,930

emission but we already looked at the

1363

00:56:29,409 --> 00:56:32,929

ratio of the software to da choppah we

1364

00:56:31,929 --> 00:56:36,289

know those are those are

1365

00:56:32,929 --> 00:56:39,199

I this guy does not have very much o3

1366

00:56:36,289 --> 00:56:41,210

and so it comes out looking kind of

1367

00:56:39,199 --> 00:56:43,189

greenish yellow combination of the H

1368

00:56:41,210 --> 00:56:46,579

alpha and the sulphur to so that that

1369
00:56:43,190 --> 00:56:48,318
all kind of hangs together so you say

1370
00:56:46,579 --> 00:56:51,170
wow look at that guy there's a nice

1371
00:56:48,318 --> 00:56:52,849
bright possibly oxygen dominated

1372
00:56:51,170 --> 00:56:54,800
supernova remnant right well it turns

1373
00:56:52,849 --> 00:56:56,990
out that's a planetary nebula in m83

1374
00:56:54,800 --> 00:56:59,630
there's no x-ray emission associated

1375
00:56:56,989 --> 00:57:05,419
with that and so that was a close but no

1376
00:56:59,630 --> 00:57:06,950
cigar in that case so with Hubble what

1377
00:57:05,420 --> 00:57:09,170
we do is we go and we get the size of

1378
00:57:06,949 --> 00:57:11,088
these guys and we actually find some

1379
00:57:09,170 --> 00:57:13,099
additional objects as well because in

1380
00:57:11,088 --> 00:57:15,049
those confused regions at ground-based

1381
00:57:13,099 --> 00:57:16,760
resolution you you you can't find them

1382
00:57:15,050 --> 00:57:19,849
and sometimes the Hubble that they pop

1383
00:57:16,760 --> 00:57:22,670
out so here are seven fields of Hubble

1384
00:57:19,849 --> 00:57:24,380
data with c3 these two green ones were

1385
00:57:22,670 --> 00:57:25,730
actually taken shortly after the last

1386
00:57:24,380 --> 00:57:27,710
servicing mission when the camera was

1387
00:57:25,730 --> 00:57:29,179
first installed and then I came back

1388
00:57:27,710 --> 00:57:31,639
with a team and we got these other five

1389
00:57:29,179 --> 00:57:33,529
fields to kind of round out the coverage

1390
00:57:31,639 --> 00:57:34,940
and get most of the galaxies and we

1391
00:57:33,530 --> 00:57:36,589
looked at it with a bunch of continuum

1392
00:57:34,940 --> 00:57:38,179
filters the star filters and then we

1393
00:57:36,588 --> 00:57:40,250
looked at it with a bunch of these

1394
00:57:38,179 --> 00:57:43,548
emission line filters and played this

1395
00:57:40,250 --> 00:57:44,809
game over that whole galaxy and that's

1396
00:57:43,548 --> 00:57:49,309
what it looks like when you stitch it

1397

00:57:44,809 --> 00:57:52,430
all together and thanks to Zoltan Levay

1398
00:57:49,309 --> 00:57:54,079
here at the Institute for for putting

1399
00:57:52,429 --> 00:57:56,389
that pretty pretty version of it

1400
00:57:54,079 --> 00:57:58,099
together but also thanks to a couple of

1401
00:57:56,389 --> 00:57:59,989
folks here Jennifer Mack and Derek

1402
00:57:58,099 --> 00:58:02,210
hammer who are the ones that figured out

1403
00:57:59,989 --> 00:58:04,068
all the alignments and all the tweaks to

1404
00:58:02,210 --> 00:58:06,829
get it all lined up properly so that

1405
00:58:04,068 --> 00:58:08,808
Zolt could could work as magic on that

1406
00:58:06,829 --> 00:58:11,030
picture and if it looks sort of familiar

1407
00:58:08,809 --> 00:58:12,890
to you but not that familiar to you well

1408
00:58:11,030 --> 00:58:14,780
if you kind of you know cut off this

1409
00:58:12,889 --> 00:58:16,190
little wing out here and just made a

1410
00:58:14,780 --> 00:58:17,839
nice rectangle out of that and turned it

1411
00:58:16,190 --> 00:58:19,159

around sideways you get this nice

1412
00:58:17,838 --> 00:58:22,389
picture of the version that was put out

1413
00:58:19,159 --> 00:58:25,009
as a press release back in January 2014

1414
00:58:22,389 --> 00:58:26,449
that's the same data set scaled a little

1415
00:58:25,010 --> 00:58:28,790
bit differently shows the Stars a little

1416
00:58:26,449 --> 00:58:30,919
bit more dramatically and so forth but

1417
00:58:28,789 --> 00:58:33,048
that's that's a pretty famous Hubble

1418
00:58:30,920 --> 00:58:36,349
picture now and it's the same data set

1419
00:58:33,048 --> 00:58:37,670
that I'll be talking about so it's nice

1420
00:58:36,349 --> 00:58:39,920
to look at the beautiful picture of the

1421
00:58:37,670 --> 00:58:41,088
whole galaxy like this but the real

1422
00:58:39,920 --> 00:58:42,409
power of Hubble is when you start

1423
00:58:41,088 --> 00:58:45,110
zooming into it where you can see the

1424
00:58:42,409 --> 00:58:47,480
details and here are a couple

1425
00:58:45,110 --> 00:58:48,340
this is still a very large area 5,000

1426
00:58:47,480 --> 00:58:51,260
light years across

1427
00:58:48,340 --> 00:58:53,660
showing dust lanes the star formation

1428
00:58:51,260 --> 00:58:54,950
going on in here

1429
00:58:53,659 --> 00:58:56,359
this is a little closer in toward the

1430
00:58:54,949 --> 00:58:57,980
nucleus you can sit tell from the

1431
00:58:56,360 --> 00:59:00,380
background and you could just see the

1432
00:58:57,980 --> 00:59:02,840
tremendous dust lanes and stuff in this

1433
00:59:00,380 --> 00:59:05,840
galaxy but behind that these tremendous

1434
00:59:02,840 --> 00:59:07,490
regions of star formation also going on

1435
00:59:05,840 --> 00:59:11,660
the red regions of course there were

1436
00:59:07,489 --> 00:59:14,449
hydrogen gas is being ionized by the

1437
00:59:11,659 --> 00:59:16,399
Starlight you that only happens for the

1438
00:59:14,449 --> 00:59:18,619
first maybe five million years after a

1439
00:59:16,400 --> 00:59:20,180
burst of star formation maybe ten

1440
00:59:18,619 --> 00:59:23,119
million years on the outside edge and

1441
00:59:20,179 --> 00:59:24,919
you lose that H alpha emission and it

1442
00:59:23,119 --> 00:59:27,650
leaves behind the stars and it might

1443
00:59:24,920 --> 00:59:30,380
look something like this very young star

1444
00:59:27,650 --> 00:59:31,550
forming regions very compact and

1445
00:59:30,380 --> 00:59:33,079
condensed you can see that there's

1446
00:59:31,550 --> 00:59:35,180
bright light in there lots of stars

1447
00:59:33,079 --> 00:59:36,829
there's not even resolved forming but

1448
00:59:35,179 --> 00:59:39,049
they're ionizing the gas around them

1449
00:59:36,829 --> 00:59:41,299
then maybe a little longer along the way

1450
00:59:39,050 --> 00:59:42,950
that that cluster of stars has had

1451
00:59:41,300 --> 00:59:44,480
enough time the stellar winds and a few

1452
00:59:42,949 --> 00:59:46,639
supernovae we have started to blow a

1453
00:59:44,480 --> 00:59:48,590
bubble and they're starting to move that

1454

00:59:46,639 --> 00:59:51,049
stuff away from the site of star

1455
00:59:48,590 --> 00:59:53,450
formation and then maybe you know 50 70

1456
00:59:51,050 --> 00:59:55,670
million years later that material has

1457
00:59:53,449 --> 00:59:57,859
all been dispersed and you're left with

1458
00:59:55,670 --> 00:59:59,570
a cluster of still fairly young stars

1459
00:59:57,860 --> 01:00:01,940
but you see there's a lot more red dots

1460
00:59:59,570 --> 01:00:03,170
in here those are red giant stars some

1461
01:00:01,940 --> 01:00:05,780
of the more massive stars that are now

1462
01:00:03,170 --> 01:00:08,389
started to evolve away from being blue

1463
01:00:05,780 --> 01:00:09,920
and become red giant stars so you can

1464
01:00:08,389 --> 01:00:11,690
actually look at the stellar component

1465
01:00:09,920 --> 01:00:14,440
and understand a lot about what's

1466
01:00:11,690 --> 01:00:17,059
happening with star formation

1467
01:00:14,440 --> 01:00:19,579
interestingly enough we don't find

1468
01:00:17,059 --> 01:00:22,130

supernovae in places like this now it's

1469

01:00:19,579 --> 01:00:24,049

partly because supernova remnants I'm

1470

01:00:22,130 --> 01:00:26,180

sorry we don't find them in regions like

1471

01:00:24,050 --> 01:00:27,680

this because the gas has all been

1472

01:00:26,179 --> 01:00:29,059

cleared out if you blow something up in

1473

01:00:27,679 --> 01:00:32,269

there it just expands out and it doesn't

1474

01:00:29,059 --> 01:00:34,519

hit anything so it never gets bright so

1475

01:00:32,269 --> 01:00:36,019

we no doubt are missing some supernova

1476

01:00:34,519 --> 01:00:38,599

remnants that happened in that in that

1477

01:00:36,019 --> 01:00:41,150

scenario but we tend to find supernova

1478

01:00:38,599 --> 01:00:44,360

remnants in regions around regions like

1479

01:00:41,150 --> 01:00:46,789

this and so for instance here is one

1480

01:00:44,360 --> 01:00:48,500

example and I'll just real briefly tell

1481

01:00:46,789 --> 01:00:50,389

you I'm not going to talk about this in

1482

01:00:48,500 --> 01:00:52,489

any detail but there's an infrared iron

1483
01:00:50,389 --> 01:00:54,500
to line that Hubble Hubble's infrared

1484
01:00:52,489 --> 01:00:56,288
channel can observe that turns out to be

1485
01:00:54,500 --> 01:00:59,259
a very nice diagnostic for

1486
01:00:56,289 --> 01:01:00,670
Jacque heated gas in this case I'm we're

1487
01:00:59,259 --> 01:01:03,039
losing the data up there but you can see

1488
01:01:00,670 --> 01:01:05,108
that this this h2 region that's

1489
01:01:03,039 --> 01:01:07,390
associated up here just is not there at

1490
01:01:05,108 --> 01:01:10,568
all in iron - and this little dot here

1491
01:01:07,389 --> 01:01:12,548
is that's a clue white means it's strong

1492
01:01:10,568 --> 01:01:14,889
in all three of my bands right it's not

1493
01:01:12,548 --> 01:01:16,478
an oxygen dominated guy but it's it's

1494
01:01:14,889 --> 01:01:18,938
bright and all three bands whereas but

1495
01:01:16,478 --> 01:01:21,548
photo wine nice stuff is not and so

1496
01:01:18,938 --> 01:01:23,288
that's a clue and it's very tiny this I

1497
01:01:21,548 --> 01:01:25,150
don't have it marked on here but that

1498
01:01:23,289 --> 01:01:26,799
circle is three arc seconds across so

1499
01:01:25,150 --> 01:01:28,929
that's way below one arc second and

1500
01:01:26,798 --> 01:01:30,909
sighs that little dot there's no star

1501
01:01:28,929 --> 01:01:33,338
there so it's not a subtraction problem

1502
01:01:30,909 --> 01:01:36,399
or anything like that and it's a strong

1503
01:01:33,338 --> 01:01:40,358
soft x-ray source so that is a young

1504
01:01:36,400 --> 01:01:42,849
supernova remnant in m83 doesn't look

1505
01:01:40,358 --> 01:01:44,949
like much but some of them are a little

1506
01:01:42,849 --> 01:01:48,099
more extended here's a little region of

1507
01:01:44,949 --> 01:01:50,139
m83 where there's a five of them in one

1508
01:01:48,099 --> 01:01:52,269
small region and so some of these guys

1509
01:01:50,139 --> 01:01:54,548
this is the emission line band over here

1510
01:01:52,268 --> 01:01:56,228
you can see little shell shapes to these

1511

01:01:54,548 --> 01:01:58,838
guys and whatnot so they're resolved

1512
01:01:56,228 --> 01:02:00,788
this one's a little more funky up here

1513
01:01:58,838 --> 01:02:02,858
all of them are bright and iron which is

1514
01:02:00,789 --> 01:02:05,019
nice to see as a matter of fact here's

1515
01:02:02,858 --> 01:02:07,778
one that's bright an iron that we don't

1516
01:02:05,018 --> 01:02:09,608
see optically we don't see an x-ray and

1517
01:02:07,778 --> 01:02:12,068
that's because it's against this dark

1518
01:02:09,608 --> 01:02:14,949
lane it's probably behind the dust and

1519
01:02:12,068 --> 01:02:17,139
this infrared line actually gets through

1520
01:02:14,949 --> 01:02:18,670
the dust and so we're finding ones that

1521
01:02:17,139 --> 01:02:20,920
we would miss otherwise because we've

1522
01:02:18,670 --> 01:02:22,539
got that iron picture as part of the

1523
01:02:20,920 --> 01:02:23,979
part of the thing but so there's five

1524
01:02:22,539 --> 01:02:26,439
supernova round this one that was not

1525
01:02:23,978 --> 01:02:28,118

known before and here we can now come in

1526

01:02:26,438 --> 01:02:30,068

and measure the sizes of those guys and

1527

01:02:28,119 --> 01:02:35,229

actually use that to understand the

1528

01:02:30,068 --> 01:02:37,389

evolution so I like to show this one

1529

01:02:35,228 --> 01:02:41,588

because this is basically a Cygnus loop

1530

01:02:37,389 --> 01:02:43,958

a big you know 7080 light year across

1531

01:02:41,588 --> 01:02:47,828

object you can see the shell is resolved

1532

01:02:43,958 --> 01:02:48,909

there it's strong at iron - there's you

1533

01:02:47,829 --> 01:02:50,949

know some stars in the region but

1534

01:02:48,909 --> 01:02:52,868

nothing that would contaminate it that

1535

01:02:50,949 --> 01:02:54,909

badly and it's a strong soft x-ray

1536

01:02:52,869 --> 01:02:57,039

source I have a spectrum of this one

1537

01:02:54,909 --> 01:02:58,420

here's the oxygen lines and the and the

1538

01:02:57,039 --> 01:03:00,339

hydrogen line that's in the blue part of

1539

01:02:58,420 --> 01:03:01,479

the spectrum and this is the red part of

1540
01:03:00,338 --> 01:03:03,728
the spectrum you can see the strong

1541
01:03:01,478 --> 01:03:06,098
sulfur lines compared to hydrogen and

1542
01:03:03,728 --> 01:03:09,399
nitrogen just what you like to see and

1543
01:03:06,099 --> 01:03:09,640
again no evidence of broadening above

1544
01:03:09,400 --> 01:03:12,220
the

1545
01:03:09,639 --> 01:03:14,588
instrumental profile in the spectrum so

1546
01:03:12,219 --> 01:03:19,689
that's that's a Cygnus loop in a MIDI

1547
01:03:14,588 --> 01:03:21,250
315 million light-years away so we'll

1548
01:03:19,690 --> 01:03:22,630
come back to the young remnants in a

1549
01:03:21,250 --> 01:03:24,278
minute but I wanted to talk about the

1550
01:03:22,630 --> 01:03:28,599
historical supernova again for a minute

1551
01:03:24,278 --> 01:03:30,039
and in particular this object that 1957

1552
01:03:28,599 --> 01:03:33,338
D so that's a supernova that was

1553
01:03:30,039 --> 01:03:35,740
observed in 1957 so we know how old that

1554
01:03:33,338 --> 01:03:37,119
one is and then this object down here

1555
01:03:35,739 --> 01:03:40,479
that we found that I think is is

1556
01:03:37,119 --> 01:03:41,980
comparable in some ways to was

1557
01:03:40,480 --> 01:03:43,809
definitely a young supernova remnant is

1558
01:03:41,980 --> 01:03:49,000
in some ways it's similar in some ways

1559
01:03:43,809 --> 01:03:51,160
it's different from from 57 D so here's

1560
01:03:49,000 --> 01:03:53,318
a couple of pictures this is the Chandra

1561
01:03:51,159 --> 01:03:55,960
x-ray picture in this case it's a blue

1562
01:03:53,318 --> 01:03:57,278
hard x-ray source which is not typical

1563
01:03:55,960 --> 01:03:59,470
for a supernova in this so usually these

1564
01:03:57,278 --> 01:04:01,179
red colors I might mean it's kind of

1565
01:03:59,469 --> 01:04:03,699
pulsar in it because pulsars have a

1566
01:04:01,179 --> 01:04:05,528
different kind of x-ray spectrum okay at

1567
01:04:03,699 --> 01:04:07,868
ground-based resolution this is what it

1568

01:04:05,528 --> 01:04:10,420
looked like there was a blue dot oxygen

1569
01:04:07,869 --> 01:04:11,588
blue dot and it had some red stuff next

1570
01:04:10,420 --> 01:04:13,568
to it but we really couldn't see what

1571
01:04:11,588 --> 01:04:15,068
was going on and so these two now are

1572
01:04:13,568 --> 01:04:17,380
the Hubble pictures that have been

1573
01:04:15,068 --> 01:04:19,028
zoomed in to that little yellow circle

1574
01:04:17,380 --> 01:04:20,950
up there so we're just looking at that

1575
01:04:19,028 --> 01:04:25,088
region and sure enough what do we see

1576
01:04:20,949 --> 01:04:26,980
blue dominated by oxygen 3 that's the 57

1577
01:04:25,088 --> 01:04:29,230
D and here's some H alpha emission

1578
01:04:26,980 --> 01:04:31,170
that's associated nearby but it is not

1579
01:04:29,230 --> 01:04:34,568
not part of that structure that we see

1580
01:04:31,170 --> 01:04:36,338
there and so that should show broad

1581
01:04:34,568 --> 01:04:37,690
oxygen lines if we're know what we're

1582
01:04:36,338 --> 01:04:40,838

doing and sure enough in the spectra

1583

01:04:37,690 --> 01:04:42,880

here we have the oxygen line and it's

1584

01:04:40,838 --> 01:04:46,150

very very broad interestingly enough

1585

01:04:42,880 --> 01:04:48,099

from 1989 to 2011 when we got the last

1586

01:04:46,150 --> 01:04:50,230

spectrum it's actually faded quite a bit

1587

01:04:48,099 --> 01:04:52,630

but it's still there still broad lines

1588

01:04:50,230 --> 01:04:53,289

it's associated with a little cluster of

1589

01:04:52,630 --> 01:04:55,028

stars

1590

01:04:53,289 --> 01:04:56,710

this is Hubble data as well on the stars

1591

01:04:55,028 --> 01:04:58,798

and we can actually go in and do

1592

01:04:56,710 --> 01:05:01,000

photometry for those stars and

1593

01:04:58,798 --> 01:05:02,920

understand what the most massive stars

1594

01:05:01,000 --> 01:05:05,108

that are in that cluster are and the

1595

01:05:02,920 --> 01:05:07,539

most massive stars are about 17 times

1596

01:05:05,108 --> 01:05:09,940

the mass of the Sun so if this one blew

1597
01:05:07,539 --> 01:05:11,650
up we had to be more massive than that

1598
01:05:09,940 --> 01:05:13,150
because the more massive they are the

1599
01:05:11,650 --> 01:05:15,759
faster they go through their life cycle

1600
01:05:13,150 --> 01:05:17,318
would blow up so it tells us it confirms

1601
01:05:15,759 --> 01:05:21,940
basically there this had to be a massive

1602
01:05:17,318 --> 01:05:23,380
star that that blew up so that's the 57

1603
01:05:21,940 --> 01:05:26,420
D guy

1604
01:05:23,380 --> 01:05:28,608
this other one just take a minute to

1605
01:05:26,420 --> 01:05:30,920
explain these are ground-based pictures

1606
01:05:28,608 --> 01:05:33,078
this is the Hubble pictures zoomed in

1607
01:05:30,920 --> 01:05:34,818
again so the scale changes between those

1608
01:05:33,079 --> 01:05:36,979
two and here's the spectrum of that

1609
01:05:34,818 --> 01:05:38,838
object that we found after after the

1610
01:05:36,978 --> 01:05:42,468
fact the story goes like this

1611
01:05:38,838 --> 01:05:44,268
we we found this object in our

1612
01:05:42,469 --> 01:05:45,979
ground-based data we actually thought

1613
01:05:44,268 --> 01:05:48,078
that there was a larger object and that

1614
01:05:45,978 --> 01:05:51,798
this was a bright not maybe on one side

1615
01:05:48,079 --> 01:05:53,599
of the shell there but when we looked at

1616
01:05:51,798 --> 01:05:55,130
the x-ray data the x-ray data really

1617
01:05:53,599 --> 01:05:57,229
seemed to line up with that bright dot

1618
01:05:55,130 --> 01:05:58,940
up there and so we came in with a

1619
01:05:57,228 --> 01:06:01,189
spectrograph and took a spectrum of that

1620
01:05:58,940 --> 01:06:04,219
dot and this is what it looked like and

1621
01:06:01,190 --> 01:06:05,749
it's very broad lines very high

1622
01:06:04,219 --> 01:06:08,358
expansion velocity so it's a young

1623
01:06:05,748 --> 01:06:10,728
object and the reason we found this with

1624
01:06:08,358 --> 01:06:12,498
our three little filters right I put an

1625

01:06:10,728 --> 01:06:13,759
H off of narrow filter there and a

1626
01:06:12,498 --> 01:06:15,649
software to filter there and it looked

1627
01:06:13,759 --> 01:06:18,019
like it was strong and software to 2h

1628
01:06:15,650 --> 01:06:19,700
alpha and yet it's got this huge feature

1629
01:06:18,018 --> 01:06:22,278
that goes over that entire region of the

1630
01:06:19,699 --> 01:06:24,498
spectrum so I just got lucky on Yellin

1631
01:06:22,278 --> 01:06:26,088
and it does have the oxygen as well so

1632
01:06:24,498 --> 01:06:28,699
we found that it is an interesting

1633
01:06:26,088 --> 01:06:31,130
object but we didn't know that it was

1634
01:06:28,699 --> 01:06:33,558
had this high velocity until we got the

1635
01:06:31,130 --> 01:06:36,108
spectrum of it well now we bring Hubble

1636
01:06:33,559 --> 01:06:38,269
into the picture because Hubble can see

1637
01:06:36,108 --> 01:06:39,978
the bright night and it actually can't

1638
01:06:38,268 --> 01:06:42,139
detect the low surface brightness stuff

1639
01:06:39,978 --> 01:06:45,618

adjacent to it there but here's H alpha

1640

01:06:42,139 --> 01:06:48,588

sulphur 203 just like you know filters

1641

01:06:45,619 --> 01:06:50,180

got gaya and but it's very very tiny

1642

01:06:48,588 --> 01:06:52,548

it's just a dot it looks like a star

1643

01:06:50,179 --> 01:06:54,679

it's not as unresolved it's very tiny

1644

01:06:52,548 --> 01:06:58,248

so from the upper limit on the size of

1645

01:06:54,679 --> 01:07:00,018

the object and the expansion velocity

1646

01:06:58,248 --> 01:07:01,338

that we got from the spectrum we can say

1647

01:07:00,018 --> 01:07:03,318

that it has to be less than a hundred

1648

01:07:01,338 --> 01:07:06,380

years old so this is the one that we

1649

01:07:03,318 --> 01:07:09,849

think is a young supernova remnant that

1650

01:07:06,380 --> 01:07:12,528

where the supernova was not observed

1651

01:07:09,849 --> 01:07:14,960

well okay so we're trying to find these

1652

01:07:12,528 --> 01:07:16,608

young guys and what did we find

1653

01:07:14,960 --> 01:07:19,429

well if we just look at the sizes of

1654
01:07:16,608 --> 01:07:21,978
them the ones that are less than that 35

1655
01:07:19,429 --> 01:07:25,639
light years 11 parsecs forgot to change

1656
01:07:21,978 --> 01:07:26,960
that sorry sighs we found about the

1657
01:07:25,639 --> 01:07:28,308
right number of objects we've got 60

1658
01:07:26,960 --> 01:07:30,608
objects that are about the right size

1659
01:07:28,309 --> 01:07:34,210
that are tiny little supernova remnants

1660
01:07:30,608 --> 01:07:36,710
number of them are x-ray sources as well

1661
01:07:34,210 --> 01:07:36,949
but the only those two objects that I

1662
01:07:36,710 --> 01:07:38,480
show

1663
01:07:36,949 --> 01:07:42,199
you and one more that I'll show you in a

1664
01:07:38,480 --> 01:07:44,358
minute that looked anything like we

1665
01:07:42,199 --> 01:07:47,059
expected for those ejected dominated

1666
01:07:44,358 --> 01:07:50,088
objects what do the rest of them look

1667
01:07:47,059 --> 01:07:51,108
like well they look like this like kind

1668
01:07:50,088 --> 01:07:54,170
of like that when I showed you a minute

1669
01:07:51,108 --> 01:07:56,630
ago here's another one a tiny little dot

1670
01:07:54,170 --> 01:07:59,630
white right in all three bands not

1671
01:07:56,630 --> 01:08:02,059
dominated by blue by the oxygen strong

1672
01:07:59,630 --> 01:08:04,300
iron source strong soft x-ray source

1673
01:08:02,059 --> 01:08:07,219
there's a few stars in the neighborhood

1674
01:08:04,300 --> 01:08:10,490
fairly blue stars so one of them blew up

1675
01:08:07,219 --> 01:08:13,819
and we take the spectrum no high

1676
01:08:10,489 --> 01:08:17,179
velocities this object is the size of

1677
01:08:13,820 --> 01:08:20,270
Cassiopeia A and yet it has no high

1678
01:08:17,180 --> 01:08:24,319
velocity material and its spectrum looks

1679
01:08:20,270 --> 01:08:26,989
like the Cygnus loop or the other ejecta

1680
01:08:24,319 --> 01:08:28,520
or not the other is M dominated

1681
01:08:26,988 --> 01:08:31,389
inspector the normal supernova resonance

1682

01:08:28,520 --> 01:08:35,210
it does not show evidence of being

1683
01:08:31,390 --> 01:08:37,700
ejected dominated so where are all the

1684
01:08:35,210 --> 01:08:39,350
KSA's this is the third object that has

1685
01:08:37,699 --> 01:08:40,988
some hope of being a castaway we don't

1686
01:08:39,350 --> 01:08:45,650
have a spectrum of this one yet but

1687
01:08:40,988 --> 01:08:47,778
again in oxygen and here's the there's

1688
01:08:45,649 --> 01:08:49,548
no star right there it's right on the

1689
01:08:47,779 --> 01:08:50,810
edge of the bright nucleus of the galaxy

1690
01:08:49,548 --> 01:08:52,519
that right over here is the bright

1691
01:08:50,810 --> 01:08:55,880
bright nucleus of the galaxy so this is

1692
01:08:52,520 --> 01:08:58,640
right on the edge this guy magenta color

1693
01:08:55,880 --> 01:09:00,469
means it's bright an H alpha and o3 it's

1694
01:08:58,640 --> 01:09:03,109
not what we expect exactly but it does

1695
01:09:00,469 --> 01:09:05,149
have the strong L 3 it is very compact

1696
01:09:03,109 --> 01:09:06,350

and there's no star there so I I think

1697

01:09:05,149 --> 01:09:07,670

if we get a spectrum with this that we

1698

01:09:06,350 --> 01:09:09,500

have some hope of maybe seeing high

1699

01:09:07,670 --> 01:09:12,500

velocities and that one so that's the

1700

01:09:09,500 --> 01:09:14,750

third one that's kind of like Cassie but

1701

01:09:12,500 --> 01:09:16,759

we're not finding 60 or hundred of these

1702

01:09:14,750 --> 01:09:18,350

things like we expected even and we

1703

01:09:16,759 --> 01:09:22,670

found the young ones and they don't look

1704

01:09:18,350 --> 01:09:25,370

like this so here's what's going on

1705

01:09:22,670 --> 01:09:27,230

apparently we're seeing we're not seeing

1706

01:09:25,369 --> 01:09:29,088

counterparts to these local ones that

1707

01:09:27,229 --> 01:09:31,329

we've seen where they get this big and

1708

01:09:29,088 --> 01:09:34,338

still show evidence of high velocity and

1709

01:09:31,329 --> 01:09:38,210

ejecta dominated we're seeing things the

1710

01:09:34,338 --> 01:09:39,890

size of Cassie or the crab that already

1711
01:09:38,210 --> 01:09:42,230
looked like the Cygnus loop that have

1712
01:09:39,890 --> 01:09:43,880
evolved beyond the ejecta dominated

1713
01:09:42,229 --> 01:09:45,738
phase into this phase where you're

1714
01:09:43,880 --> 01:09:49,730
looking at shocked interstellar gas

1715
01:09:45,738 --> 01:09:50,659
surrounding the object so the supernova

1716
01:09:49,729 --> 01:09:53,799
remnants and m83

1717
01:09:50,659 --> 01:09:56,300
you're evolving very quickly beyond the

1718
01:09:53,800 --> 01:10:00,980
ejecta phase and into the what's called

1719
01:09:56,300 --> 01:10:03,680
the radiative phase of evolution so we

1720
01:10:00,979 --> 01:10:05,839
didn't find what we expected to find and

1721
01:10:03,680 --> 01:10:07,520
these cards will be on sale in the lobby

1722
01:10:05,840 --> 01:10:10,940
if you wanted I want to send it to me

1723
01:10:07,520 --> 01:10:12,380
after the meeting you know because you

1724
01:10:10,939 --> 01:10:13,699
know sometimes it doesn't work out the

1725
01:10:12,380 --> 01:10:17,750
way you expect it to work out you know

1726
01:10:13,699 --> 01:10:21,349
but so I guess this is probably the most

1727
01:10:17,750 --> 01:10:26,119
most appropriate one for my situation if

1728
01:10:21,350 --> 01:10:27,980
you but when science gives you lemons

1729
01:10:26,119 --> 01:10:30,050
well you make lemonade right and so

1730
01:10:27,979 --> 01:10:31,519
we've learned a lot we've learned some

1731
01:10:30,050 --> 01:10:33,619
really interesting things about this

1732
01:10:31,520 --> 01:10:35,980
galaxy and a couple of things that I

1733
01:10:33,619 --> 01:10:38,689
really didn't highlight to you too much

1734
01:10:35,979 --> 01:10:42,079
I'll do number two here first basically

1735
01:10:38,689 --> 01:10:44,029
m83 has very high chemical element

1736
01:10:42,079 --> 01:10:46,850
abundances even compared to the Milky

1737
01:10:44,029 --> 01:10:48,619
Way we had the small Magellanic Cloud

1738
01:10:46,850 --> 01:10:52,400
the Large Magellanic Cloud the Milky Way

1739

01:10:48,619 --> 01:10:54,920
and m83 the abundances go from about 0.2

1740
01:10:52,399 --> 01:10:57,969
times the sun's abundance to about 0.5

1741
01:10:54,920 --> 01:11:01,640
and the LMC to the Milky Way abundances

1742
01:10:57,970 --> 01:11:04,010
this galaxy has twice solar abundances

1743
01:11:01,640 --> 01:11:06,650
over that entire galaxy and probably

1744
01:11:04,010 --> 01:11:08,390
even higher in the center and I think

1745
01:11:06,649 --> 01:11:10,879
those high abundances are part of the

1746
01:11:08,390 --> 01:11:12,980
story the other part of it is the this

1747
01:11:10,880 --> 01:11:15,470
x-ray data remember shows all this

1748
01:11:12,979 --> 01:11:18,199
diffuse hot gas in the spiral arms

1749
01:11:15,470 --> 01:11:21,320
that's high density high pressure gas in

1750
01:11:18,199 --> 01:11:23,750
the interstellar medium of m83 so let's

1751
01:11:21,319 --> 01:11:26,119
put these two things together hi

1752
01:11:23,750 --> 01:11:27,739
chemical element abundances in a massive

1753
01:11:26,119 --> 01:11:30,319

star allow us to start to have a very

1754

01:11:27,739 --> 01:11:32,599

strong wind that would blow material off

1755

01:11:30,319 --> 01:11:35,299

before the star explodes but if we've

1756

01:11:32,600 --> 01:11:37,640

got a hot high-pressure is M around it

1757

01:11:35,300 --> 01:11:39,470

that stuff can't go very far it hangs

1758

01:11:37,640 --> 01:11:41,660

out right around the outside of where

1759

01:11:39,470 --> 01:11:44,000

the star is going to explode so when the

1760

01:11:41,659 --> 01:11:45,470

star explodes it rams into that stuff

1761

01:11:44,000 --> 01:11:47,600

very quickly and you get a bright

1762

01:11:45,470 --> 01:11:50,720

radiative supernova remnant very quickly

1763

01:11:47,600 --> 01:11:52,700

at a small diameter and so I think

1764

01:11:50,720 --> 01:11:54,140

that's what's tricked us here we're

1765

01:11:52,699 --> 01:11:57,649

finding the young remnants but they're

1766

01:11:54,140 --> 01:11:59,150

not catching them in that ejecta

1767

01:11:57,649 --> 01:12:01,759

dominated phase that we were hoping to

1768
01:11:59,149 --> 01:12:04,069
find and it turns out this is very

1769
01:12:01,760 --> 01:12:05,690
interesting and we're still trying to

1770
01:12:04,069 --> 01:12:07,908
pieced together models and things that

1771
01:12:05,689 --> 01:12:10,039
would that would help us understand

1772
01:12:07,908 --> 01:12:11,988
exactly how that all transpires but

1773
01:12:10,039 --> 01:12:16,760
that's our working model for what's

1774
01:12:11,988 --> 01:12:19,578
going on so worried basically we did

1775
01:12:16,760 --> 01:12:22,070
find a lot of young supernova remnants

1776
01:12:19,578 --> 01:12:24,799
as we expected but we did not find them

1777
01:12:22,069 --> 01:12:26,899
to be in this ejected dominated state

1778
01:12:24,800 --> 01:12:29,750
that we did expect and and I just talked

1779
01:12:26,899 --> 01:12:31,009
about the reasons I hope as we get

1780
01:12:29,750 --> 01:12:33,050
additional spectra for some of these

1781
01:12:31,010 --> 01:12:35,780
candidate objects that we might find a

1782
01:12:33,050 --> 01:12:37,610
couple more of those young objects with

1783
01:12:35,779 --> 01:12:40,519
the very broad lines like that one that

1784
01:12:37,609 --> 01:12:41,658
I showed you but that's not no guarantee

1785
01:12:40,520 --> 01:12:43,940
and it's certainly not going to get us

1786
01:12:41,658 --> 01:12:47,269
up to a hundred of those young objects

1787
01:12:43,939 --> 01:12:48,859
that way so that's it and thanks for

1788
01:12:47,270 --> 01:12:50,060
listening and this is just kind of

1789
01:12:48,859 --> 01:12:51,920
showing you where all the supernova

1790
01:12:50,060 --> 01:12:54,380
remnants are across the galaxy and the

1791
01:12:51,920 --> 01:12:55,969
optical and the x-ray pictures I'd be

1792
01:12:54,380 --> 01:12:58,810
glad to try to answer some questions for

1793
01:12:55,969 --> 01:12:58,810
you thank you very much

1794
01:13:26,510 --> 01:13:31,890
only sort of indirectly like versus that

1795
01:13:29,670 --> 01:13:33,210
one that I said from the it was seen an

1796

01:13:31,890 --> 01:13:34,860
iron and it wasn't seen in the other

1797
01:13:33,210 --> 01:13:35,909
wavelengths and that iron gets through

1798
01:13:34,859 --> 01:13:37,679
the dust and they're sitting right on

1799
01:13:35,909 --> 01:13:39,659
the dust Lane I know it must be behind

1800
01:13:37,680 --> 01:13:41,270
the dust but other than that I don't

1801
01:13:39,659 --> 01:13:44,579
really have depth into the galaxy

1802
01:13:41,270 --> 01:13:45,870
information that's very small distance

1803
01:13:44,579 --> 01:13:48,090
compared to the distance from us to the

1804
01:13:45,869 --> 01:13:49,109
galaxy so it's just they're essentially

1805
01:13:48,090 --> 01:13:52,340
all at the same distance from my

1806
01:13:49,109 --> 01:13:56,250
perspective but yeah it would be hard to

1807
01:13:52,340 --> 01:13:58,430
pin that down with any certainty yes

1808
01:13:56,250 --> 01:13:58,430
ma'am

1809
01:14:06,220 --> 01:14:10,530
in the actual supernova spectrum are in

1810
01:14:08,439 --> 01:14:10,529

the

1811

01:14:21,948 --> 01:14:33,388

so from the supernova itself basically

1812

01:14:25,908 --> 01:14:35,728

from the ejecta so the spectrum would

1813

01:14:33,389 --> 01:14:38,519

tell me and if the spectrum is emission

1814

01:14:35,729 --> 01:14:40,530

lines I can even get the composition of

1815

01:14:38,519 --> 01:14:42,360

the of the material and so for instance

1816

01:14:40,529 --> 01:14:44,609

an can say that yellow stuff in the

1817

01:14:42,359 --> 01:14:47,908

Hubble picture there was dominated by

1818

01:14:44,609 --> 01:14:51,598

oxygen and sulfur and argon and calcium

1819

01:14:47,908 --> 01:14:53,009

emission no hydrogen no nitrogen that's

1820

01:14:51,599 --> 01:14:54,360

that's a clue right there that it's a

1821

01:14:53,010 --> 01:14:56,489

massive star because that's the kind of

1822

01:14:54,359 --> 01:14:59,819

stuff you get from what's called oxygen

1823

01:14:56,488 --> 01:15:00,958

burning and so forth so you but I could

1824

01:14:59,819 --> 01:15:01,920

look in a different spot and I'd see a

1825
01:15:00,958 --> 01:15:03,569
different spectrum and it would have a

1826
01:15:01,920 --> 01:15:05,458
different composition it came from a

1827
01:15:03,569 --> 01:15:07,768
different layer in the star or whatever

1828
01:15:05,458 --> 01:15:09,630
of course as we go to m83 or longer

1829
01:15:07,769 --> 01:15:11,729
larger distances we can't see the

1830
01:15:09,630 --> 01:15:14,389
individual knots like we see in kasi and

1831
01:15:11,729 --> 01:15:16,829
so you get more of an ensemble spectrum

1832
01:15:14,389 --> 01:15:18,479
instead I if I didn't answer your

1833
01:15:16,828 --> 01:15:19,139
question come up and hold try it don't

1834
01:15:18,479 --> 01:15:32,820
try again

1835
01:15:19,139 --> 01:15:35,909
yes sir it could in principle although

1836
01:15:32,819 --> 01:15:37,408
the vast majority of the core collapse

1837
01:15:35,908 --> 01:15:39,420
remnants now the Crab Nebula is

1838
01:15:37,408 --> 01:15:41,938
different I'll give you that but most of

1839
01:15:39,420 --> 01:15:44,368
them explode there they're flying out

1840
01:15:41,939 --> 01:15:46,679
very rapidly and then eventually they're

1841
01:15:44,368 --> 01:15:47,549
going to slow down with expansion they

1842
01:15:46,679 --> 01:15:50,309
still down with time they don't

1843
01:15:47,550 --> 01:15:52,019
accelerate the Crab Nebula is different

1844
01:15:50,309 --> 01:15:54,510
because it's got that active pulsar in

1845
01:15:52,019 --> 01:15:56,820
there and that pulsar that's spinning

1846
01:15:54,510 --> 01:16:00,530
pulsar you got a one point four solar

1847
01:15:56,819 --> 01:16:03,179
mass object spinning 30 times a second

1848
01:16:00,529 --> 01:16:04,649
mind-boggling so that energy coming off

1849
01:16:03,179 --> 01:16:06,090
of that had particles and magnetic

1850
01:16:04,649 --> 01:16:08,788
fields and whatnot is what energizes

1851
01:16:06,090 --> 01:16:11,939
that blue diffuse gas in the middle of

1852
01:16:08,788 --> 01:16:13,170
the Crab Nebula and that synchrotron is

1853

01:16:11,939 --> 01:16:15,539
called synchrotron emission that

1854
01:16:13,170 --> 01:16:17,609
emission is actually pushing out on the

1855
01:16:15,538 --> 01:16:19,279
filaments and accelerating them so

1856
01:16:17,609 --> 01:16:21,299
they're actually going faster with time

1857
01:16:19,279 --> 01:16:23,130
even though it's only going 1,800

1858
01:16:21,300 --> 01:16:25,288
kilometers per second compared to 10,000

1859
01:16:23,130 --> 01:16:27,179
that was a must have been a low-energy

1860
01:16:25,288 --> 01:16:29,038
explosion or something that just didn't

1861
01:16:27,179 --> 01:16:31,649
start it off that fast but it's actually

1862
01:16:29,038 --> 01:16:33,748
being accelerated yeah now but most of

1863
01:16:31,649 --> 01:16:34,769
them it's just boom it goes off they fly

1864
01:16:33,748 --> 01:16:38,789
out and eventually

1865
01:16:34,770 --> 01:16:40,830
slow down yeah yeah so for cafe for

1866
01:16:38,789 --> 01:16:43,170
instance interesting enough can't say

1867
01:16:40,829 --> 01:16:45,539

this young is 340 plus or minus a few

1868

01:16:43,170 --> 01:16:49,079

year object in our own galaxy the

1869

01:16:45,539 --> 01:16:52,260

supernova was not seen in 16 roughly

1870

01:16:49,079 --> 01:16:54,720

1680 and here we've got the Chinese have

1871

01:16:52,260 --> 01:16:58,530

observations to go back to yellow BC

1872

01:16:54,720 --> 01:17:00,300

times right and and as somehow in 1680

1873

01:16:58,529 --> 01:17:01,649

even with European observers and it was

1874

01:17:00,300 --> 01:17:02,159

placed well in the northern sky and

1875

01:17:01,649 --> 01:17:04,829

everything like that

1876

01:17:02,159 --> 01:17:07,949

they didn't see the supernova now maybe

1877

01:17:04,829 --> 01:17:10,050

it was a sub luminous supernova but even

1878

01:17:07,949 --> 01:17:12,300

so it's in our galaxy it shouldn't it

1879

01:17:10,050 --> 01:17:14,460

should have been easily visible probably

1880

01:17:12,300 --> 01:17:16,409

but to get the age of it they look at

1881

01:17:14,460 --> 01:17:20,000

the fastest material they see flying out

1882
01:17:16,409 --> 01:17:22,949
right now assume that's unda celebrated

1883
01:17:20,000 --> 01:17:24,119
and look at its proper motion and then

1884
01:17:22,949 --> 01:17:25,970
they take that backwards in time and

1885
01:17:24,119 --> 01:17:35,430
that's how they came up with the 1680

1886
01:17:25,970 --> 01:17:37,530
number for that one you know that is

1887
01:17:35,430 --> 01:17:41,070
difficult to determine supernova

1888
01:17:37,529 --> 01:17:43,469
remnants from type 1a supernovae versus

1889
01:17:41,069 --> 01:17:45,149
core-collapse how does that uncertainty

1890
01:17:43,470 --> 01:17:48,210
play into the star formation

1891
01:17:45,149 --> 01:17:49,920
calculations or other information so the

1892
01:17:48,210 --> 01:17:51,510
idea is you were looking at it this you

1893
01:17:49,920 --> 01:17:52,980
showed a lot in the spectra that you're

1894
01:17:51,510 --> 01:17:55,050
you know almost I almost sort of a

1895
01:17:52,979 --> 01:17:57,809
case-by-case basis you have to figure

1896
01:17:55,050 --> 01:17:59,880
out what the progenitor was right how

1897
01:17:57,810 --> 01:18:01,500
does that play into the star formation

1898
01:17:59,880 --> 01:18:04,500
rate that calculations what I do with

1899
01:18:01,500 --> 01:18:07,020
this yeah so it's an area of ongoing

1900
01:18:04,500 --> 01:18:08,579
research basically once the objects have

1901
01:18:07,020 --> 01:18:10,590
expanded to the point that they're just

1902
01:18:08,579 --> 01:18:12,659
shocking the interstellar gas around

1903
01:18:10,590 --> 01:18:13,860
them and expanding you can't tell what

1904
01:18:12,659 --> 01:18:16,289
kind of a star it was that blew up

1905
01:18:13,859 --> 01:18:19,979
without knowledge of the supernova

1906
01:18:16,289 --> 01:18:23,039
itself but you can play some games you

1907
01:18:19,979 --> 01:18:24,809
can say wow here's the supernova remnant

1908
01:18:23,039 --> 01:18:27,600
it's right next to this big cluster of

1909
01:18:24,810 --> 01:18:29,550
blue blue massive stars probably a core

1910

01:18:27,600 --> 01:18:31,320
collapse even if you didn't see the

1911
01:18:29,550 --> 01:18:33,270
supernova right and then taking it the

1912
01:18:31,319 --> 01:18:34,679
other way when you see a supernova room

1913
01:18:33,270 --> 01:18:38,760
that it's kind of out in the middle of

1914
01:18:34,680 --> 01:18:40,320
nowhere and there's no young star

1915
01:18:38,760 --> 01:18:42,860
cluster around or anything like that you

1916
01:18:40,319 --> 01:18:45,420
could say that was probably a type 1a

1917
01:18:42,859 --> 01:18:46,859
exploding white dwarf type 1a

1918
01:18:45,420 --> 01:18:49,500
supernovae there's different types of

1919
01:18:46,859 --> 01:18:51,299
supernovae and so you could look at an

1920
01:18:49,500 --> 01:18:54,149
ensemble in a galaxy like this Medina

1921
01:18:51,300 --> 01:18:55,529
1031 in particular and they try to make

1922
01:18:54,149 --> 01:18:57,299
those correlations and try to look at

1923
01:18:55,529 --> 01:18:58,738
those subsets separate from each other

1924
01:18:57,300 --> 01:19:01,349

and see if they can find correlations

1925

01:18:58,738 --> 01:19:02,698
and stuff like that but it's it's an

1926

01:19:01,349 --> 01:19:06,510
uncertain business if you haven't seen

1927

01:19:02,698 --> 01:19:12,868
the supernova yeah you know other

1928

01:19:06,510 --> 01:19:16,130
questions i warm down I check online to

1929

01:19:12,868 --> 01:19:16,130
see if there's any more online

1930

01:19:19,198 --> 01:19:21,899
yeah you've already answered the

1931

01:19:20,579 --> 01:19:24,948
question about how you determine the age

1932

01:19:21,899 --> 01:19:24,948
of supernova remnant

1933

01:19:52,659 --> 01:19:58,309
well they're mostly in the comments are

1934

01:19:55,609 --> 01:20:00,710
mostly ice they have an admixture it's

1935

01:19:58,310 --> 01:20:02,630
just basically whatever came together to

1936

01:20:00,710 --> 01:20:03,859
make the object right so what depending

1937

01:20:02,630 --> 01:20:05,900
on what part of the solar system they

1938

01:20:03,859 --> 01:20:07,219
formed and what the materials were

1939
01:20:05,899 --> 01:20:11,689
around when they form they have

1940
01:20:07,220 --> 01:20:13,670
different admixture of ices versus rocky

1941
01:20:11,689 --> 01:20:16,460
dusty stuff you know there's a lot we

1942
01:20:13,670 --> 01:20:17,899
look at your stars that are forming

1943
01:20:16,460 --> 01:20:20,480
planets right now and they have discs of

1944
01:20:17,899 --> 01:20:22,489
dust and gas around them that's the

1945
01:20:20,479 --> 01:20:24,079
stuff that some of which ends up making

1946
01:20:22,489 --> 01:20:26,389
comments right and so it's it's a

1947
01:20:24,079 --> 01:20:27,829
mixture of gas and dust and you just get

1948
01:20:26,390 --> 01:20:30,890
different comets will have a slightly

1949
01:20:27,829 --> 01:20:32,300
different mixture of those temperature

1950
01:20:30,890 --> 01:20:34,010
would be a big factor yeah right well

1951
01:20:32,300 --> 01:20:35,869
also you recognize that if you examine

1952
01:20:34,010 --> 01:20:39,409
the surface of a comet you're not going

1953
01:20:35,869 --> 01:20:42,229
to find a lot of fresh ice because as it

1954
01:20:39,409 --> 01:20:44,840
goes goes past those volatiles will go

1955
01:20:42,229 --> 01:20:47,059
away on the surface of the comet so at

1956
01:20:44,840 --> 01:20:49,369
the part of the idea the Deep Impact

1957
01:20:47,060 --> 01:20:52,130
mission was to try and look at the

1958
01:20:49,369 --> 01:20:55,090
subsurface material that spews out when

1959
01:20:52,130 --> 01:20:59,289
we basically through a washing machine

1960
01:20:55,090 --> 01:21:08,420
into a comet at 25,000 miles an hour by

1961
01:20:59,289 --> 01:21:09,439
my analogy yeah okay is there somebody

1962
01:21:08,420 --> 01:21:11,329
from the Maryland Space Grant

1963
01:21:09,439 --> 01:21:14,179
Observatory here to take people across

1964
01:21:11,329 --> 01:21:17,840
the street I do not see that person I

1965
01:21:14,180 --> 01:21:20,000
will talk to them next month and make

1966
01:21:17,840 --> 01:21:23,630
sure that they either show up or let me

1967

01:21:20,000 --> 01:21:26,270
know with an email let's see next month

1968
01:21:23,630 --> 01:21:31,100
we have Toby marriage talking about the

1969
01:21:26,270 --> 01:21:34,310
cosmology large angular scale survey and

1970
01:21:31,100 --> 01:21:35,810
that will be on November 1st all right

1971
01:21:34,310 --> 01:21:39,050
that is a week before Election Day so

1972
01:21:35,810 --> 01:21:40,720
you know you can won't have to deal with

1973
01:21:39,050 --> 01:21:43,190
any of the election stuff that night

1974
01:21:40,720 --> 01:21:44,750
hopefully we maybe will have to deal

1975
01:21:43,189 --> 01:21:46,969
with the a the oriole so I wouldn't

1976
01:21:44,750 --> 01:21:48,350
wouldn't mind it that that happened but

1977
01:21:46,970 --> 01:21:50,829
ladies and gentlemen let's give Bill one

1978
01:21:48,350 --> 01:21:50,829
more hand

1979
01:21:57,390 --> 01:22:05,079
did anybody leave a thermal cup the

1980
01:22:03,010 --> 01:22:08,289
facilities found this two months ago I

1981
01:22:05,079 --> 01:22:12,789

think in August they handed it to me

1982

01:22:08,289 --> 01:22:16,319

last month after the talk your price

1983

01:22:12,789 --> 01:22:16,319

door please have a drink

1984

01:22:26,779 --> 01:22:32,149

you're welcome but with what you were