1
00:00:21,510 --> 00:00:18,150
welcome to hubble's universe unfiltered

2
00:00:23,109 --> 00:00:21,520
the year 2015 was the 25th anniversary

3
00:00:24,310 --> 00:00:23,119
of the launch of the hubble space

4
00:00:26,470 --> 00:00:24,320
telescope

5
00:00:29,509 --> 00:00:26,480
and every year for the anniversary we

6
00:00:31,830 --> 00:00:29,519
produce a special image to celebrate

7
00:00:34,229 --> 00:00:31,840
now it's kind of hard after all the

8
00:00:35,670 --> 00:00:34,239
amazing images that hubble has produced

9
00:00:37,910 --> 00:00:35,680
to find one image that's more

10
00:00:40,229 --> 00:00:37,920
spectacular than all the others

11
00:00:42,630 --> 00:00:40,239
however for the 25th anniversary we

12
00:00:45,910 --> 00:00:42,640
wanted to do something special so we

13
00:00:47,670 --> 00:00:45,920

made it stand out in a different way

14
00:00:49,510 --> 00:00:47,680
let me orient you

15
00:00:50,869 --> 00:00:49,520
toward the target

16
00:00:53,990 --> 00:00:50,879
this video

17
00:00:56,389 --> 00:00:54,000
starts in the karina constellation which

18
00:00:58,389 --> 00:00:56,399
features the wonderful karina nebula

19
00:01:00,630 --> 00:00:58,399
that hubble has looked at many times but

20
00:01:02,869 --> 00:01:00,640
that's not the target there are several

21
00:01:04,869 --> 00:01:02,879
smaller nebula to its right

22
00:01:07,510 --> 00:01:04,879
and this nebula is the target it's

23
00:01:09,109 --> 00:01:07,520
called gum29

24
00:01:11,910 --> 00:01:09,119
this is a ground-based image of the

25
00:01:15,429 --> 00:01:11,920
nebula gum29 and you can see it consists

26
00:01:18,550 --> 00:01:15,439
of a star cluster and its associated gas

27
00:01:21,670 --> 00:01:18,560
the ultraviolet light from the stars is

28
00:01:24,870 --> 00:01:21,680
heating the gas and causing it to glow

29
00:01:27,030 --> 00:01:24,880
however if we look in infrared light

30
00:01:28,149 --> 00:01:27,040
this is an image from the spitzer space

31
00:01:30,310 --> 00:01:28,159
telescope

32
00:01:32,789 --> 00:01:30,320
we can see that the gas is actually

33
00:01:35,350 --> 00:01:32,799
warmed over a much larger region than we

34
00:01:37,350 --> 00:01:35,360
see in visible light we zoom in towards

35
00:01:39,830 --> 00:01:37,360
the center of the star cluster and

36
00:01:43,590 --> 00:01:39,840
nasa's other great observatory the

37
00:01:45,749 --> 00:01:43,600
chandra x-ray telescope took this image

38
00:01:48,069 --> 00:01:45,759

of the star cluster

39
00:01:50,789 --> 00:01:48,079
and you can see the copious amounts of

40
00:01:52,870 --> 00:01:50,799
x-rays coming from that star cluster

41
00:01:54,469 --> 00:01:52,880
which indicates these must be very

42
00:01:56,149 --> 00:01:54,479
massive stars

43
00:01:59,749 --> 00:01:56,159
getting a lot of x-rays indicates you've

44
00:02:00,709 --> 00:01:59,759
got a really massive star cluster here

45
00:02:03,590 --> 00:02:00,719
so

46
00:02:05,429 --> 00:02:03,600
looking at those images gave us optimism

47
00:02:06,789 --> 00:02:05,439
that this was going to be a really cool

48
00:02:08,309 --> 00:02:06,799
image from hubble

49
00:02:10,309 --> 00:02:08,319
so here is the field of view in the

50
00:02:11,510 --> 00:02:10,319
spitzer image that hubble viewed with

51
00:02:12,790 --> 00:02:11,520
visible light

52
00:02:16,070 --> 00:02:12,800
and hubble

53
00:02:18,949 --> 00:02:16,080
has much better resolution than spitzer

54
00:02:21,430 --> 00:02:18,959
so this was the release image of the

55
00:02:24,150 --> 00:02:21,440
nebula gum 29 and the star cluster

56
00:02:25,830 --> 00:02:24,160
westerlund 2 at its core

57
00:02:27,910 --> 00:02:25,840
and the resolution is even better than

58
00:02:30,710 --> 00:02:27,920
i'm showing you here because this image

59
00:02:33,509 --> 00:02:30,720
is about 9 000 pixels across

60
00:02:35,910 --> 00:02:33,519
so if i zoom into that star cluster you

61
00:02:38,309 --> 00:02:35,920
can see it breaks up into an amazing

62
00:02:41,509 --> 00:02:38,319
number of stars there are several

63
00:02:43,030 --> 00:02:41,519

thousand massive bright stars in this

64
00:02:45,830 --> 00:02:43,040
cluster

65
00:02:49,190 --> 00:02:45,840
if i look along the nebula wall we see a

66
00:02:51,190 --> 00:02:49,200
whole range of these pillars we've seen

67
00:02:53,750 --> 00:02:51,200
lots of pillars with hubble well here we

68
00:02:57,670 --> 00:02:53,760
have several of them all in one region

69
00:02:59,750 --> 00:02:57,680
along the wall of the nebula of gum29

70
00:03:02,470 --> 00:02:59,760
we also have one of these pillars bathed

71
00:03:04,949 --> 00:03:02,480
in sort of this purple glow and so

72
00:03:05,830 --> 00:03:04,959
there's a lot of cool details in this

73
00:03:07,589 --> 00:03:05,840
image

74
00:03:09,910 --> 00:03:07,599
and hubble was able to get a really

75
00:03:12,149 --> 00:03:09,920
wonderfully high resolution and all

76
00:03:14,470 --> 00:03:12,159
sorts of interesting details

77
00:03:16,470 --> 00:03:14,480
now to make it special

78
00:03:19,110 --> 00:03:16,480
i work in the visualization group and

79
00:03:22,710 --> 00:03:19,120
they asked us to take this and take this

80
00:03:25,110 --> 00:03:22,720
2d image and pull it out into 3d

81
00:03:27,110 --> 00:03:25,120
to remind you that these aren't 2d

82
00:03:29,030 --> 00:03:27,120
picture postcards of the night sky

83
00:03:31,350 --> 00:03:29,040
they're really representations of a

84
00:03:33,670 --> 00:03:31,360
three-dimensional universe

85
00:03:36,149 --> 00:03:33,680
well to do that visualization we

86
00:03:38,789 --> 00:03:36,159
recognize that this press release image

87
00:03:40,789 --> 00:03:38,799
was actually part of a slightly larger

88
00:03:42,710 --> 00:03:40,799

region this was the full image that we

89
00:03:44,710 --> 00:03:42,720
took with hubble and we cropped down to

90
00:03:46,710 --> 00:03:44,720
that for the press release image

91
00:03:49,190 --> 00:03:46,720
and we're going to take that full image

92
00:03:51,190 --> 00:03:49,200
and place it on top of the ground-based

93
00:03:53,110 --> 00:03:51,200
image to give you context

94
00:03:55,270 --> 00:03:53,120
now when we do a visualization we want a

95
00:03:57,429 --> 00:03:55,280
widescreen aspect ratio

96
00:04:00,309 --> 00:03:57,439
so we cropped it down to the widescreen

97
00:04:02,149 --> 00:04:00,319
aspect ratio we blended the hubble image

98
00:04:03,750 --> 00:04:02,159
and the background image together and

99
00:04:05,670 --> 00:04:03,760
this was our starting point for our

100
00:04:07,509 --> 00:04:05,680
visualization

101
00:04:10,070 --> 00:04:07,519
now we want to take a look at that

102
00:04:13,910 --> 00:04:10,080
nebula but you've got all these stars in

103
00:04:15,830 --> 00:04:13,920
the way so the first thing we do is boom

104
00:04:18,069 --> 00:04:15,840
get rid of all the stars

105
00:04:20,229 --> 00:04:18,079
now i love giving talks and being able

106
00:04:22,230 --> 00:04:20,239
to go one slide to the next and having

107
00:04:24,310 --> 00:04:22,240
all those stars disappear but of course

108
00:04:27,189 --> 00:04:24,320
you should recognize that's a tremendous

109
00:04:28,870 --> 00:04:27,199
amount of work by our visualization team

110
00:04:31,990 --> 00:04:28,880
and of course once we get rid of those

111
00:04:35,030 --> 00:04:32,000
stars we have to bring them back in

112
00:04:37,510 --> 00:04:35,040
for this we developed a new technique of

113
00:04:39,270 --> 00:04:37,520

a point spread function stars now let me

114
00:04:40,070 --> 00:04:39,280
explain what that is

115
00:04:42,710 --> 00:04:40,080
so

116
00:04:45,749 --> 00:04:42,720
when hubble observes a star that star is

117
00:04:48,230 --> 00:04:45,759
just a point of light and the brighter

118
00:04:50,070 --> 00:04:48,240
stars get bigger on hubble's detectors

119
00:04:52,950 --> 00:04:50,080
and they spread out

120
00:04:55,350 --> 00:04:52,960
so we characterize very carefully

121
00:04:58,550 --> 00:04:55,360
how a point spreads out on hubble's

122
00:04:59,590 --> 00:04:58,560
detectors we call that the point spread

123
00:05:01,110 --> 00:04:59,600
function

124
00:05:02,870 --> 00:05:01,120
we astronomers are pretty straight

125
00:05:04,710 --> 00:05:02,880
forward to what we call things

126
00:05:06,550 --> 00:05:04,720
here is an example of one of hubble's

127
00:05:09,270 --> 00:05:06,560
point spread functions so you can see in

128
00:05:10,870 --> 00:05:09,280
the upper left it's just a dot and as

129
00:05:11,830 --> 00:05:10,880
you come towards the

130
00:05:14,150 --> 00:05:11,840
across

131
00:05:15,909 --> 00:05:14,160
and down it gets brighter and brighter

132
00:05:18,870 --> 00:05:15,919
and the star gets bigger and also

133
00:05:20,870 --> 00:05:18,880
develops these diff diffraction spikes

134
00:05:23,029 --> 00:05:20,880
this is what a star looks like in one of

135
00:05:24,629 --> 00:05:23,039
hubble's detectors as one gets brighter

136
00:05:27,590 --> 00:05:24,639
and brighter stars

137
00:05:30,150 --> 00:05:27,600
knowing that we can go in

138
00:05:32,710 --> 00:05:30,160

and examine the hubble image

139
00:05:35,270 --> 00:05:32,720
and characterize those stars

140
00:05:36,950 --> 00:05:35,280
so we did it in three different filters

141
00:05:39,270 --> 00:05:36,960
one that will be red one that'll be

142
00:05:41,350 --> 00:05:39,280
green and one that will be blue

143
00:05:43,350 --> 00:05:41,360
we measured the positions of all those

144
00:05:45,110 --> 00:05:43,360
stars and their brightnesses in the

145
00:05:47,350 --> 00:05:45,120
three different filters

146
00:05:49,990 --> 00:05:47,360
and then using the point spread function

147
00:05:51,590 --> 00:05:50,000
we could recreate those stars

148
00:05:53,670 --> 00:05:51,600
artificially well i don't wanna say

149
00:05:55,590 --> 00:05:53,680
artificially more synthetically we can

150
00:05:57,189 --> 00:05:55,600
create them digitally without you know

151
00:05:59,350 --> 00:05:57,199
going into the image and cutting out

152
00:06:02,550 --> 00:05:59,360
little postage straps around each star

153
00:06:04,550 --> 00:06:02,560
we could go in and create them digitally

154
00:06:06,870 --> 00:06:04,560
furthermore you may notice that the

155
00:06:09,189 --> 00:06:06,880
stars of the cluster are significantly

156
00:06:11,110 --> 00:06:09,199
redder than the other stars

157
00:06:12,870 --> 00:06:11,120
that helps us pull out the stars in the

158
00:06:14,390 --> 00:06:12,880
cluster and separate it from the stars

159
00:06:16,550 --> 00:06:14,400
in the foreground

160
00:06:18,469 --> 00:06:16,560
we do that with what astronomers call a

161
00:06:20,390 --> 00:06:18,479
color color diagram

162
00:06:22,710 --> 00:06:20,400
and basically it's just a way of

163
00:06:24,309 --> 00:06:22,720

separating which stars are redder or

164
00:06:26,309 --> 00:06:24,319
bluer than the others

165
00:06:28,309 --> 00:06:26,319
and in the left-hand panel you can see

166
00:06:31,350 --> 00:06:28,319
that white line well those are the

167
00:06:32,870 --> 00:06:31,360
foreground stars and the red clump well

168
00:06:34,550 --> 00:06:32,880
those are the stars we identified as

169
00:06:36,230 --> 00:06:34,560
being part of the cluster

170
00:06:37,830 --> 00:06:36,240
here in the middle panel we've got all

171
00:06:40,150 --> 00:06:37,840
the stars together with the cluster

172
00:06:42,629 --> 00:06:40,160
stars colored red and in the right panel

173
00:06:44,950 --> 00:06:42,639
we have the foreground stars using this

174
00:06:46,710 --> 00:06:44,960
color color diagram enabled us to do a

175
00:06:48,070 --> 00:06:46,720
pretty good separation between the stars

176
00:06:49,830 --> 00:06:48,080
of the cluster and the stars in the

177
00:06:51,510 --> 00:06:49,840
foreground you can see it wasn't a

178
00:06:54,629 --> 00:06:51,520
perfect separation there's a little over

179
00:06:56,629 --> 00:06:54,639
density in the foreground stars but for

180
00:06:58,150 --> 00:06:56,639
the purposes of this visualization it's

181
00:07:01,270 --> 00:06:58,160
quite sufficient

182
00:07:03,909 --> 00:07:01,280
so here are the stars of the cluster

183
00:07:05,830 --> 00:07:03,919
and the foreground stars all created

184
00:07:07,270 --> 00:07:05,840
synthetically using point spread

185
00:07:09,510 --> 00:07:07,280
functions

186
00:07:11,350 --> 00:07:09,520
now you'll notice there are empty spaces

187
00:07:13,430 --> 00:07:11,360
on either side where we blend it into

188
00:07:15,749 --> 00:07:13,440

the ground-based image

189
00:07:18,870 --> 00:07:15,759
to do that we had to go to another

190
00:07:21,430 --> 00:07:18,880
catalog from the 2-mass survey

191
00:07:23,909 --> 00:07:21,440
and we gathered stars from a wide region

192
00:07:27,110 --> 00:07:23,919
around this area and then identified

193
00:07:30,390 --> 00:07:27,120
those that were in our field of view but

194
00:07:32,870 --> 00:07:30,400
not inside the hubble part of the image

195
00:07:35,670 --> 00:07:32,880
this is an infrared catalog so we had to

196
00:07:37,670 --> 00:07:35,680
take the band passes in infrared map

197
00:07:39,749 --> 00:07:37,680
them to the hubble band passes and

198
00:07:41,350 --> 00:07:39,759
adjust the magnitudes appropriately to

199
00:07:43,589 --> 00:07:41,360
get the proper colors

200
00:07:46,230 --> 00:07:43,599
again we use the hubble psf

201
00:07:49,350 --> 00:07:46,240
and we ended up being able to fill in

202
00:07:50,950 --> 00:07:49,360
the stars on the outer part of the field

203
00:07:53,110 --> 00:07:50,960
altogether

204
00:07:56,230 --> 00:07:53,120
here are all the stars done with this

205
00:07:57,830 --> 00:07:56,240
point spread function technique

206
00:08:00,469 --> 00:07:57,840
now we've got to deal with the nebula

207
00:08:02,550 --> 00:08:00,479
itself and the nebula has several parts

208
00:08:05,350 --> 00:08:02,560
you can see here's the foreground gas on

209
00:08:07,589 --> 00:08:05,360
the near side of the nebula here are all

210
00:08:09,510 --> 00:08:07,599
these pillars along the inner edge of

211
00:08:11,510 --> 00:08:09,520
the nebula and then we've got that

212
00:08:12,629 --> 00:08:11,520
bright gas in the background part of the

213
00:08:14,390 --> 00:08:12,639

nebula

214
00:08:16,629 --> 00:08:14,400
each of those is going to be a separate

215
00:08:18,150 --> 00:08:16,639
layer inside the nebula and we're going

216
00:08:20,150 --> 00:08:18,160
to do it with a technique we call

217
00:08:21,990 --> 00:08:20,160
sculpted decoupage

218
00:08:23,110 --> 00:08:22,000
let me explain a little bit

219
00:08:25,830 --> 00:08:23,120
here is

220
00:08:27,909 --> 00:08:25,840
an image called the great wave of canada

221
00:08:29,350 --> 00:08:27,919
and it has several layers in it you can

222
00:08:31,029 --> 00:08:29,360
see that you've got the wave in the

223
00:08:32,310 --> 00:08:31,039
foreground you've got the mountains in

224
00:08:34,469 --> 00:08:32,320
the background

225
00:08:36,230 --> 00:08:34,479
and if you take that image multiple

226
00:08:37,430 --> 00:08:36,240
times and slice it up into the various

227
00:08:41,509 --> 00:08:37,440
pieces

228
00:08:43,909 --> 00:08:41,519
together with little separators in them

229
00:08:47,269 --> 00:08:43,919
you can create what's called a decoupage

230
00:08:49,030 --> 00:08:47,279
box here is an actual decoupage box and

231
00:08:50,949 --> 00:08:49,040
here are views of it

232
00:08:53,990 --> 00:08:50,959
from different angles showing how you

233
00:08:56,870 --> 00:08:54,000
get a 3d technique by simply putting in

234
00:08:58,310 --> 00:08:56,880
multiple layers of the same image

235
00:09:00,150 --> 00:08:58,320
well we're going to do the same sort of

236
00:09:02,230 --> 00:09:00,160
thing digitally

237
00:09:04,550 --> 00:09:02,240
but we're also not going to use just

238
00:09:05,829 --> 00:09:04,560

flat layers we're going to sculpt each

239
00:09:08,389 --> 00:09:05,839
of those layers

240
00:09:10,790 --> 00:09:08,399
so for example these are the layers in

241
00:09:12,710 --> 00:09:10,800
our digital model that represent the

242
00:09:14,310 --> 00:09:12,720
background of the nebula and you see how

243
00:09:15,910 --> 00:09:14,320
they have sort of a bowl shape because

244
00:09:17,750 --> 00:09:15,920
that's how the background part of the

245
00:09:20,150 --> 00:09:17,760
nebula would look

246
00:09:21,190 --> 00:09:20,160
here are the layers that represent the

247
00:09:22,630 --> 00:09:21,200
pillars

248
00:09:24,389 --> 00:09:22,640
and you'll notice that one of them is

249
00:09:26,389 --> 00:09:24,399
tilted because we want to make sure all

250
00:09:28,790 --> 00:09:26,399
of those pillars point towards the star

251
00:09:30,470 --> 00:09:28,800
cluster because it is the energetic

252
00:09:32,470 --> 00:09:30,480
radiation from the star cluster that is

253
00:09:36,389 --> 00:09:32,480
creating those pillars all those pillars

254
00:09:37,990 --> 00:09:36,399
point in 3d towards that star cluster

255
00:09:40,389 --> 00:09:38,000
here are the layers that are on the

256
00:09:42,790 --> 00:09:40,399
foreground of the nebula

257
00:09:44,310 --> 00:09:42,800
and finally we have a layer just in

258
00:09:46,310 --> 00:09:44,320
front of the nebula called the veil

259
00:09:48,829 --> 00:09:46,320
which is a layer of thin gas that sort

260
00:09:53,110 --> 00:09:48,839
of forms a bubble along the front of the

261
00:09:55,030 --> 00:09:53,120
nebula add to that the cluster stars

262
00:09:55,990 --> 00:09:55,040
as well as the foreground stars from

263
00:09:58,310 --> 00:09:56,000

hubble

264
00:09:59,829 --> 00:09:58,320
and then the foreground stars from the

265
00:10:02,790 --> 00:09:59,839
surrounding region

266
00:10:04,790 --> 00:10:02,800
together you get the full

267
00:10:06,630 --> 00:10:04,800
3d model that we use for our

268
00:10:08,870 --> 00:10:06,640
visualization

269
00:10:11,430 --> 00:10:08,880
looks kind of like a christmas tree

270
00:10:13,350 --> 00:10:11,440
of course this is a side view of it and

271
00:10:15,590 --> 00:10:13,360
the camera would actually be located at

272
00:10:18,870 --> 00:10:15,600
the top of the tree

273
00:10:20,949 --> 00:10:18,880
here is a movie showing you a build up

274
00:10:22,630 --> 00:10:20,959
from back to front

275
00:10:23,829 --> 00:10:22,640
we start with the background layers of

276
00:10:26,069 --> 00:10:23,839
the nebula

277
00:10:28,949 --> 00:10:26,079
the brighter gas add in the cluster

278
00:10:31,110 --> 00:10:28,959
stars and then all of those individual

279
00:10:32,470 --> 00:10:31,120
little pillars along the inner edge of

280
00:10:34,069 --> 00:10:32,480
the nebula

281
00:10:35,269 --> 00:10:34,079
then we start with several layers for

282
00:10:38,949 --> 00:10:35,279
the foreground

283
00:10:40,949 --> 00:10:38,959
add in the veil layers and finally add

284
00:10:42,949 --> 00:10:40,959
in the stars

285
00:10:44,870 --> 00:10:42,959
now we have ourselves a full

286
00:12:09,350 --> 00:10:44,880
three-dimensional model and we can

287
00:12:13,910 --> 00:12:11,590
we called that visualization celestial

288
00:12:16,310 --> 00:12:13,920

fireworks both for the large number of

289
00:12:18,230 --> 00:12:16,320
very bright stars in that cluster as

290
00:12:20,230 --> 00:12:18,240
well as for the celebration of hubble's

291
00:12:22,230 --> 00:12:20,240
25th anniversary

292
00:12:26,150 --> 00:12:22,240
i thought it was a fitting addition to

293
00:12:27,750 --> 00:12:26,160
an amazing panoply of hubble's imagery

294
00:12:29,269 --> 00:12:27,760
thank you for watching we'll see you