1
00:00:14,638 --> 00:00:21,189
welcome to Hubble's universe unfiltered

2
00:00:17,429 --> 00:00:23,079
the year 2015 was the 25th anniversary

3
00:00:21,189 --> 00:00:25,539
of the launch of the Hubble Space

4
00:00:23,079 --> 00:00:27,879
Telescope and every year for the

5
00:00:25,539 --> 00:00:31,509
anniversary we produce a special image

6
00:00:27,879 --> 00:00:33,640
to celebrate now it's kind of hard after

7
00:00:31,509 --> 00:00:35,829
all the amazing images that Hubble has

8
00:00:33,640 --> 00:00:38,439
produced to find one image that's more

9
00:00:35,829 --> 00:00:40,840
spectacular than all the others however

10
00:00:38,439 --> 00:00:43,329
for the 25th anniversary we wanted to do

11
00:00:40,840 --> 00:00:47,070
something special so we made it stand

12
00:00:43,329 --> 00:00:51,460
out in a different way let me orient you

13
00:00:47,070 --> 00:00:54,490
toward the target this video starts in

14
00:00:51,460 --> 00:00:57,009
the Carina constellation which features

15
00:00:54,490 --> 00:00:58,990
the wonderful Carina Nebula that Hubble

16
00:00:57,009 --> 00:00:59,559
has looked at many times but that's not

17
00:00:58,990 --> 00:01:01,929
the target

18
00:00:59,560 --> 00:01:04,930
there are several smaller nebula to its

19
00:01:01,929 --> 00:01:08,500
right and this nebula is the target it's

20
00:01:04,930 --> 00:01:11,259
called gum 29 this is a ground-based

21
00:01:08,500 --> 00:01:13,599
image of the nebula gum 29 and you can

22
00:01:11,259 --> 00:01:16,780
see it consists of a star cluster and

23
00:01:13,599 --> 00:01:19,599
its associated gas the ultraviolet light

24
00:01:16,780 --> 00:01:23,259
from the stars is heating the gas and

25
00:01:19,599 --> 00:01:25,989
causing it to glow however if we look in

26
00:01:23,259 --> 00:01:29,019
infrared light this is an image from the

27
00:01:25,989 --> 00:01:31,239
Spitzer Space Telescope we can see that

28
00:01:29,019 --> 00:01:33,670
the gas is actually warmed over a much

29

00:01:31,239 --> 00:01:35,888
larger region than we see in visible

30
00:01:33,670 --> 00:01:38,379
light we zoom in towards the center of

31
00:01:35,888 --> 00:01:41,468
the star cluster and NASA's other great

32
00:01:38,379 --> 00:01:45,248
Observatory the Chandra x-ray telescope

33
00:01:41,468 --> 00:01:47,919
took this image of the star cluster and

34
00:01:45,248 --> 00:01:50,408
you can see the copious amounts of

35
00:01:47,920 --> 00:01:52,599
x-rays coming from That star cluster

36
00:01:50,409 --> 00:01:55,749
which indicates these must be very

37
00:01:52,599 --> 00:01:57,339
massive stars getting a lot of x-rays

38
00:01:55,748 --> 00:02:01,539
indicates you've got a really massive

39
00:01:57,340 --> 00:02:04,209
star cluster here so looking at those

40
00:02:01,539 --> 00:02:05,950
images gave us optimism that this was

41
00:02:04,209 --> 00:02:08,348
going to be a really cool image from

42
00:02:05,950 --> 00:02:10,209
Hubble so here is the field of view in

43
00:02:08,348 --> 00:02:13,598

the spitzer image that Hubble viewed

44
00:02:10,209 --> 00:02:16,810
with visible light and Hubble has much

45
00:02:13,598 --> 00:02:19,689
better resolution than Spitzer so this

46
00:02:16,810 --> 00:02:22,909
was the release image of the nebula Gumm

47
00:02:19,689 --> 00:02:25,699
29 and the star cluster Westerlund 2 at

48
00:02:22,909 --> 00:02:27,620
score and the resolution is even better

49
00:02:25,699 --> 00:02:31,129
than I'm showing you here because this

50
00:02:27,620 --> 00:02:33,770
image is about 9000 pixels across so if

51
00:02:31,129 --> 00:02:36,199
i zoom into that star cluster you can

52
00:02:33,770 --> 00:02:38,930
see it breaks up into an amazing number

53
00:02:36,199 --> 00:02:42,429
of stars there are several thousand

54
00:02:38,930 --> 00:02:45,770
massive bright stars in this cluster if

55
00:02:42,430 --> 00:02:49,280
I look along the nebula wall we see a

56
00:02:45,770 --> 00:02:51,260
whole range of these pillars we've seen

57
00:02:49,280 --> 00:02:53,629
lots of pillars with Hubble well here we

58
00:02:51,259 --> 00:02:56,919
have several of them all in one region

59
00:02:53,629 --> 00:02:59,659
along the wall of the nebula of gum 29

60
00:02:56,919 --> 00:03:02,359
we also have one of these pillars bathed

61
00:02:59,659 --> 00:03:04,879
in sort of this purple glow and so

62
00:03:02,360 --> 00:03:07,130
there's a lot of cool details in this

63
00:03:04,879 --> 00:03:09,439
image and Hubble was able to get a

64
00:03:07,129 --> 00:03:12,799
really wonderfully high resolution and

65
00:03:09,439 --> 00:03:15,289
all sorts of interesting details now to

66
00:03:12,800 --> 00:03:17,630
make it special I work in the

67
00:03:15,289 --> 00:03:20,120
visualization group and they asked us to

68
00:03:17,629 --> 00:03:23,930
take this and take this 2d image and

69
00:03:20,120 --> 00:03:26,150
pull it out into 3d to remind you that

70
00:03:23,930 --> 00:03:28,640
these aren't 2d picture postcards of the

71
00:03:26,150 --> 00:03:32,030
night sky they're really representations

72
00:03:28,639 --> 00:03:34,369
of a three-dimensional universe well to

73
00:03:32,030 --> 00:03:36,620
do that visualization we recognize that

74
00:03:34,370 --> 00:03:39,650
this press-release image was actually

75
00:03:36,620 --> 00:03:41,300
part of a slightly larger region this

76
00:03:39,650 --> 00:03:43,250
was the full image that we took with

77
00:03:41,300 --> 00:03:45,170
Hubble and we cropped down to that for

78
00:03:43,250 --> 00:03:47,509
the press release image and we're going

79
00:03:45,169 --> 00:03:49,849
to take that full image and place it on

80
00:03:47,509 --> 00:03:52,009
top of the ground-based image to give

81
00:03:49,849 --> 00:03:53,659
you context now when we do a

82
00:03:52,009 --> 00:03:56,689
visualization we want a widescreen

83
00:03:53,659 --> 00:03:59,299
aspect ratio so we cropped it down to

84
00:03:56,689 --> 00:04:01,129
the widescreen aspect ratio we blended

85
00:03:59,300 --> 00:04:02,989
the Hubble image and the background

86

00:04:01,129 --> 00:04:06,979
image together and this was our starting

87
00:04:02,989 --> 00:04:08,780
point for our visualization now we want

88
00:04:06,979 --> 00:04:11,299
to take a look at that nebula but you've

89
00:04:08,780 --> 00:04:14,569
got all these stars in the way so the

90
00:04:11,300 --> 00:04:17,810
first thing we do is boom get rid of all

91
00:04:14,569 --> 00:04:19,849
the stars wow I love giving talks and

92
00:04:17,810 --> 00:04:22,069
being able to go one slide to the next

93
00:04:19,850 --> 00:04:23,600
and having all those stars disappear but

94
00:04:22,069 --> 00:04:25,639
of course you should recognize that's a

95
00:04:23,600 --> 00:04:28,340
tremendous amount of work by our

96
00:04:25,639 --> 00:04:30,409
visualization team and of course once we

97
00:04:28,339 --> 00:04:33,560
get rid of those stars we have to bring

98
00:04:30,410 --> 00:04:35,840
them back in for this we developed a new

99
00:04:33,560 --> 00:04:36,680
technique of a point spread function

100
00:04:35,839 --> 00:04:40,339

star

101
00:04:36,680 --> 00:04:43,100
now let me explain what that is so when

102
00:04:40,339 --> 00:04:45,888
Hubble observes a star that star is just

103
00:04:43,100 --> 00:04:48,110
a point of light and the brighter stars

104
00:04:45,889 --> 00:04:51,769
get bigger on Hubble's detectors and

105
00:04:48,110 --> 00:04:55,100
they spread out so we characterized very

106
00:04:51,769 --> 00:04:57,529
carefully how a point spreads out on

107
00:04:55,100 --> 00:05:00,560
Hubble's detectors we call that the

108
00:04:57,529 --> 00:05:02,000
point spread function we astronomers are

109
00:05:00,560 --> 00:05:04,579
pretty straight forward to what we call

110
00:05:02,000 --> 00:05:06,319
things here is an example of one of

111
00:05:04,579 --> 00:05:08,120
Hubble's point-spread functions so you

112
00:05:06,319 --> 00:05:11,300
can see in the upper left it's just a

113
00:05:08,120 --> 00:05:13,850
dot and as you come towards the across

114
00:05:11,300 --> 00:05:16,038
and down it gets brighter and brighter

115
00:05:13,850 --> 00:05:17,750
and the star gets bigger and also

116
00:05:16,038 --> 00:05:20,779
develops these different diffraction

117
00:05:17,750 --> 00:05:22,850
spikes this is what a star looks like in

118
00:05:20,779 --> 00:05:25,279
one of Hubble's detectors as one gets

119
00:05:22,850 --> 00:05:29,240
brighter and brighter stars knowing that

120
00:05:25,279 --> 00:05:33,019
we can go in and examine the Hubble

121
00:05:29,240 --> 00:05:35,629
image and characterize those stars so we

122
00:05:33,019 --> 00:05:37,549
did it in three different filters one

123
00:05:35,629 --> 00:05:40,370
that will be red one that be green and

124
00:05:37,550 --> 00:05:42,379
one that will be blue we measured the

125
00:05:40,370 --> 00:05:43,879
positions of all those stars and there

126
00:05:42,379 --> 00:05:46,699
brightnesses in the three different

127
00:05:43,879 --> 00:05:49,689
filters and then using the point spread

128
00:05:46,699 --> 00:05:51,740
function we could recreate those stars

129
00:05:49,689 --> 00:05:53,810
artificially well I don't want it

130
00:05:51,740 --> 00:05:55,668
artificially more synthetically we can

131
00:05:53,810 --> 00:05:57,259
create them digitally without you know

132
00:05:55,668 --> 00:05:58,939
going into the image and cutting out

133
00:05:57,259 --> 00:06:02,199
little postage stamps around each star

134
00:05:58,939 --> 00:06:04,699
we could go in and create them digitally

135
00:06:02,199 --> 00:06:06,889
furthermore you may notice that the

136
00:06:04,699 --> 00:06:09,860
stars of the cluster are significantly

137
00:06:06,889 --> 00:06:11,780
redder than the other stars that helps

138
00:06:09,860 --> 00:06:13,189
us pull out the stars in the cluster and

139
00:06:11,779 --> 00:06:15,799
separate it from the stars in the

140
00:06:13,189 --> 00:06:17,839
foreground we do that with what

141
00:06:15,800 --> 00:06:20,240
astronomers call a color color diagram

142
00:06:17,839 --> 00:06:22,668
and basically it's just a way of

143

00:06:20,240 --> 00:06:24,860
separating which stars are redder or

144
00:06:22,668 --> 00:06:26,959
bluer than the others and in the

145
00:06:24,860 --> 00:06:29,150
left-hand panel you can see that white

146
00:06:26,959 --> 00:06:32,120
line well those are the foreground stars

147
00:06:29,149 --> 00:06:33,560
and red clump well those are the stars

148
00:06:32,120 --> 00:06:35,990
we identified as being part of the

149
00:06:33,560 --> 00:06:37,668
cluster here in the middle panel we've

150
00:06:35,990 --> 00:06:39,650
got all the stars together with the

151
00:06:37,668 --> 00:06:41,839
cluster stars colored red and in the

152
00:06:39,649 --> 00:06:44,629
right panel we have the foreground stars

153
00:06:41,839 --> 00:06:45,978
using this color color diagram enabled

154
00:06:44,629 --> 00:06:47,718
us to do a pretty good separation

155
00:06:45,978 --> 00:06:49,430
between the stars the cluster and the

156
00:06:47,718 --> 00:06:50,360
stars in the foreground you can see it

157
00:06:49,430 --> 00:06:52,098

wasn't a perfect

158
00:06:50,360 --> 00:06:54,919
separation there's a little over density

159
00:06:52,098 --> 00:06:56,688
in the foreground stars but for the

160
00:06:54,918 --> 00:06:59,930
purposes of this visualization it's

161
00:06:56,689 --> 00:07:02,718
quite sufficient so here are the stars

162
00:06:59,930 --> 00:07:05,658
of the cluster and the foreground stars

163
00:07:02,718 --> 00:07:08,209
all created synthetically using point

164
00:07:05,658 --> 00:07:10,788
spread functions now you'll notice there

165
00:07:08,209 --> 00:07:13,728
are empty spaces on either side where we

166
00:07:10,788 --> 00:07:16,339
blend it into the ground-based image to

167
00:07:13,728 --> 00:07:20,060
do that we had to go to another catalog

168
00:07:16,339 --> 00:07:22,068
from the 2mass Survey and we gathered

169
00:07:20,060 --> 00:07:25,009
stars from a wide region around this

170
00:07:22,069 --> 00:07:28,669
area and then identify those that were

171
00:07:25,009 --> 00:07:31,009
in our field of view but not inside the

172
00:07:28,668 --> 00:07:33,408
Hubble part of the image this is an

173
00:07:31,009 --> 00:07:36,169
infrared catalog so we had to take the

174
00:07:33,408 --> 00:07:38,329
band passes an infrared map them to the

175
00:07:36,168 --> 00:07:40,218
Hubble band passes and adjust the

176
00:07:38,329 --> 00:07:42,468
magnitudes appropriately to get the

177
00:07:40,218 --> 00:07:45,649
proper colors again we use the Hubble

178
00:07:42,468 --> 00:07:48,228
PSF and we ended up being able to fill

179
00:07:45,649 --> 00:07:51,948
in the stars on the outer part of the

180
00:07:48,228 --> 00:07:53,688
field all together here are all the

181
00:07:51,949 --> 00:07:57,228
stars done with this point spread

182
00:07:53,689 --> 00:07:59,509
function technique now we've got to deal

183
00:07:57,228 --> 00:08:01,430
with the nebula itself and the nebula

184
00:07:59,509 --> 00:08:03,650
has several parts you can see here's the

185
00:08:01,430 --> 00:08:06,918
foreground gas on the near side of the

186
00:08:03,649 --> 00:08:08,299
nebula here are all these pillars along

187
00:08:06,918 --> 00:08:10,519
the inner edge of the nebula

188
00:08:08,300 --> 00:08:12,860
and then we've got that bright gas in

189
00:08:10,519 --> 00:08:14,718
the background part of the nebula each

190
00:08:12,860 --> 00:08:17,028
of those is going to be a separate layer

191
00:08:14,718 --> 00:08:18,740
inside the nebula and we're going to do

192
00:08:17,028 --> 00:08:21,310
it with a technique we call sculpted

193
00:08:18,740 --> 00:08:24,379
decoupage let me explain a little bit

194
00:08:21,310 --> 00:08:27,649
here is an image called the great wave

195
00:08:24,379 --> 00:08:29,000
of Ken Agha and it has several layers in

196
00:08:27,649 --> 00:08:30,649
it you can see that that you've got the

197
00:08:29,000 --> 00:08:32,899
wave in the foreground you've got the

198
00:08:30,649 --> 00:08:35,389
mountains in the background and if you

199
00:08:32,899 --> 00:08:37,908
take that image multiple times and slice

200

00:08:35,389 --> 00:08:39,828
it up into the various pieces you take

201
00:08:37,908 --> 00:08:42,168
those pieces and put them together with

202
00:08:39,828 --> 00:08:45,409
little separators in them you can create

203
00:08:42,168 --> 00:08:48,110
what's called a decoupage box here is an

204
00:08:45,409 --> 00:08:50,899
actual decoupage box and here are views

205
00:08:48,110 --> 00:08:53,810
of it from different angles showing how

206
00:08:50,899 --> 00:08:56,198
you get a 3d technique by simply putting

207
00:08:53,809 --> 00:08:58,399
in multiple layers of the same image

208
00:08:56,198 --> 00:09:01,818
well we're going to do the same sort of

209
00:08:58,399 --> 00:09:03,899
thing digitally but we're also not going

210
00:09:01,818 --> 00:09:06,360
to use just flat layers we're going

211
00:09:03,899 --> 00:09:08,669
sculpt each of those layers so for

212
00:09:06,360 --> 00:09:10,889
example these are the layers in our

213
00:09:08,669 --> 00:09:12,839
digital model that represent the

214
00:09:10,889 --> 00:09:14,399

background of the nebula and you see how

215
00:09:12,840 --> 00:09:16,110
they have sort of a bowl shape because

216
00:09:14,399 --> 00:09:18,720
that's how the background part of the

217
00:09:16,110 --> 00:09:21,659
nebula would look here are the layers

218
00:09:18,720 --> 00:09:23,160
that represent the pillars and you'll

219
00:09:21,659 --> 00:09:24,539
notice that one of them is tilted

220
00:09:23,159 --> 00:09:26,459
because we want to make sure all of

221
00:09:24,539 --> 00:09:28,620
those pillars point towards the star

222
00:09:26,460 --> 00:09:30,570
cluster because it is the energetic

223
00:09:28,620 --> 00:09:31,950
radiation from the star cluster that is

224
00:09:30,570 --> 00:09:34,230
creating those pillars all of those

225
00:09:31,950 --> 00:09:37,950
pillars point in 3d towards that star

226
00:09:34,230 --> 00:09:41,070
cluster here are the layers that are on

227
00:09:37,950 --> 00:09:43,350
the foreground of the nebula and finally

228
00:09:41,070 --> 00:09:45,300
we have a layer just in front of the

229
00:09:43,350 --> 00:09:47,460
nebula called the veil which is a layer

230
00:09:45,299 --> 00:09:50,669
of thin gas that sort of forms a bubble

231
00:09:47,460 --> 00:09:54,090
along the front of the nebula add to

232
00:09:50,669 --> 00:09:56,490
that the cluster stars as well as the

233
00:09:54,090 --> 00:09:58,470
foreground stars from Hubble and then

234
00:09:56,490 --> 00:10:01,889
the foreground stars from the

235
00:09:58,470 --> 00:10:04,920
surrounding region together you get the

236
00:10:01,889 --> 00:10:07,649
full 3d model that we use for our

237
00:10:04,919 --> 00:10:10,409
visualization looks kind of like

238
00:10:07,649 --> 00:10:12,480
Christmas tree of course this is a side

239
00:10:10,409 --> 00:10:15,959
view of it and the camera would actually

240
00:10:12,480 --> 00:10:19,200
be located at the top of the tree here

241
00:10:15,960 --> 00:10:21,840
is a movie showing you a build up from

242
00:10:19,200 --> 00:10:24,090
back to front we start with the

243
00:10:21,840 --> 00:10:26,850
background layers of the nebula the

244
00:10:24,090 --> 00:10:29,340
brighter gas ad in the cluster stars and

245
00:10:26,850 --> 00:10:31,350
then all of those individual little

246
00:10:29,340 --> 00:10:33,870
pillars along the inner edge of the

247
00:10:31,350 --> 00:10:36,690
nebula then we start with several layers

248
00:10:33,870 --> 00:10:41,220
for the foreground add in the veil

249
00:10:36,690 --> 00:10:42,870
layers and finally add in the stars now

250
00:10:41,220 --> 00:10:44,879
we have ourselves a full

251
00:10:42,870 --> 00:10:48,440
three-dimensional model and we can

252
00:10:44,879 --> 00:10:48,439
create the visualization

253
00:10:53,740 --> 00:10:55,799
you

254
00:12:08,809 --> 00:12:14,000
we called that visualization celestial

255
00:12:11,629 --> 00:12:15,919
fireworks both for the large number of

256
00:12:14,000 --> 00:12:18,320
very bright stars in that cluster as

257

00:12:15,919 --> 00:12:20,990
well as for the celebration of Hubble's

258
00:12:18,320 --> 00:12:23,360
25th anniversary I thought it was a

259
00:12:20,990 --> 00:12:26,810
fitting addition to an amazing panoply

260
00:12:23,360 --> 00:12:27,289
of Hubble's imagery thank you for

261
00:12:26,809 --> 00:12:28,879
watching

262
00:12:27,289 --> 00:12:31,959
we'll see you next time on Hubble's

263
00:12:28,879 --> 00:12:31,960
universe unfiltered