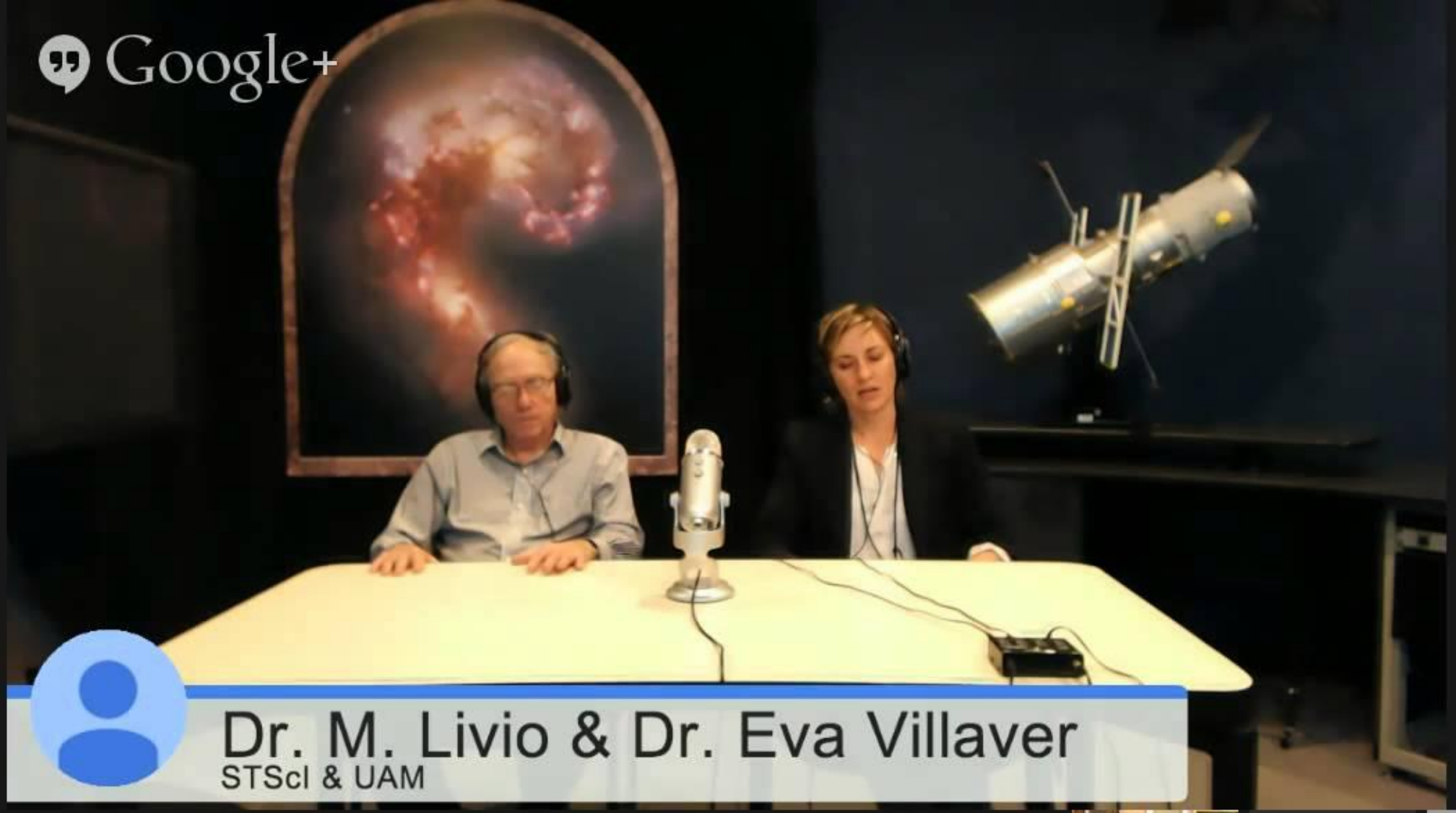
Google+
Dr. M. Livio & Dr. Eva Villaver
STScI & UAM
Elena
Carol Christian

1
00:00:06,250 --> 00:00:03,730
hello everybody and welcome to our

2
00:00:08,379 --> 00:00:06,260
latest Hubble hang out my name is Tony

3
00:00:10,390 --> 00:00:08,389
Darnell I am at the Space Telescope

4
00:00:13,449 --> 00:00:10,400
Science Institute and with me today is

5
00:00:15,520 --> 00:00:13,459
dr. again when one of our hangouts dr.

6
00:00:17,110 --> 00:00:15,530
mario livio and dr. carol christian from

7
00:00:19,450 --> 00:00:17,120
the Space Telescope Science Institute

8
00:00:21,130 --> 00:00:19,460
they've done many hangouts with me

9
00:00:24,010 --> 00:00:21,140
before on this but we're also joined by

10
00:00:26,860 --> 00:00:24,020
dr. Ava Villa ver from and let me get

11
00:00:30,250 --> 00:00:26,870
this right universidad autónoma de

12
00:00:31,630 --> 00:00:30,260
Madrid she's an astronomer and she is

13
00:00:33,579 --> 00:00:31,640

attending a symposium that we're having

14
00:00:35,439 --> 00:00:33,589
at the Institute this week that is I

15
00:00:38,919 --> 00:00:35,449
think one of the more interesting things

16
00:00:41,680 --> 00:00:38,929
we've had here at the Space Telescope

17
00:00:43,779 --> 00:00:41,690
Science Institute they are discussing

18
00:00:47,309 --> 00:00:43,789
and meeting this week to talk about

19
00:00:51,309 --> 00:00:47,319
issues associated with habitability

20
00:00:53,169 --> 00:00:51,319
habitability around planets moons what

21
00:00:54,790 --> 00:00:53,179
are the what does it mean what does

22
00:00:56,649 --> 00:00:54,800
something mean to be habitable and

23
00:00:58,599 --> 00:00:56,659
habitable for whom I mean what are we

24
00:01:00,910 --> 00:00:58,609
you know what are the what are the

25
00:01:04,509 --> 00:01:00,920
conditions that are necessary to have

26
00:01:06,429 --> 00:01:04,519
life out in the universe and at an issue

27
00:01:12,330 --> 00:01:06,439
that I'm particularly interested in also

28
00:01:14,770 --> 00:01:12,340
is how extensible is you know Earth's

29
00:01:17,260 --> 00:01:14,780
habitability requirements to everything

30
00:01:18,850 --> 00:01:17,270
else and and so there astronomers are

31
00:01:20,889 --> 00:01:18,860
meeting discussing all these really

32
00:01:23,889 --> 00:01:20,899
great questions and we're going to touch

33
00:01:27,160 --> 00:01:23,899
on some of this this right now this with

34
00:01:28,779 --> 00:01:27,170
this with this hangout Mario and Ava

35
00:01:30,580 --> 00:01:28,789
were very kind of joy to give us some of

36
00:01:32,050 --> 00:01:30,590
their time and in Carol's with us to

37
00:01:34,719 --> 00:01:32,060
give her perspective which is always

38
00:01:36,700 --> 00:01:34,729

really good to discuss this idea of

39
00:01:38,020 --> 00:01:36,710
habitability so before I get started I

40
00:01:41,679 --> 00:01:38,030
want to let you know I'm monitoring

41
00:01:43,480 --> 00:01:41,689
youtube I monitoring Google+ and if you

42
00:01:45,039 --> 00:01:43,490
use that if you are want to tweet some

43
00:01:48,520 --> 00:01:45,049
questions or comments using the Hubble

44
00:01:50,109 --> 00:01:48,530
hang out hashtag I wall i'm also

45
00:01:51,399 --> 00:01:50,119
monitoring those as well and we'll try

46
00:01:52,899 --> 00:01:51,409
to get to them if there's time at the

47
00:01:56,969 --> 00:01:52,909
end we only have a half an hour so I

48
00:01:59,529 --> 00:01:56,979
want to just jump right in habitability

49
00:02:01,779 --> 00:01:59,539
habitability i was at all this time i

50
00:02:05,919 --> 00:02:01,789
had my head mario and ava big instead of

51
00:02:09,070 --> 00:02:05,929
me what let's talk about what we mean by

52
00:02:11,530 --> 00:02:09,080
that and some mario what what's your

53
00:02:12,880 --> 00:02:11,540
impression when we say habitable what do

54
00:02:14,230 --> 00:02:12,890
you guys what do you what goes in your

55
00:02:16,790 --> 00:02:14,240
head we told my earth

56
00:02:19,910 --> 00:02:16,800
mammals microbes what do we mean by

57
00:02:22,600 --> 00:02:19,920
habitability no so unfortunately since

58
00:02:26,900 --> 00:02:22,610
we only so far discovered life on Earth

59
00:02:30,110 --> 00:02:26,910
and so we made the definition of what we

60
00:02:33,680 --> 00:02:30,120
mean by habitable so basically around

61
00:02:37,700 --> 00:02:33,690
every star you can define a range of

62
00:02:40,340 --> 00:02:37,710
distances from the star which allows for

63
00:02:44,390 --> 00:02:40,350

liquid water on the surface of that

64
00:02:47,300 --> 00:02:44,400
planet if there is a planet there then

65
00:02:49,790 --> 00:02:47,310
liquid water can exist in the particular

66
00:02:52,700 --> 00:02:49,800
case of the earth of course the earth is

67
00:02:56,030 --> 00:02:52,710
in the habitable zone around our star

68
00:02:58,850 --> 00:02:56,040
namely the Sun but because we think that

69
00:03:02,030 --> 00:02:58,860
water may be absolutely essential for

70
00:03:04,790 --> 00:03:02,040
life we define this region around any

71
00:03:07,640 --> 00:03:04,800
for any planet around any other star and

72
00:03:10,670 --> 00:03:07,650
then we've searched to see whether there

73
00:03:13,490 --> 00:03:10,680
are any planets in this habitable zone

74
00:03:16,520 --> 00:03:13,500
namely in that region that would allow

75
00:03:20,690 --> 00:03:16,530
for liquid water to be on the surface of

76
00:03:23,960 --> 00:03:20,700
that planet so this week there are a lot

77
00:03:27,830 --> 00:03:23,970
of talks being given in a wide variety

78
00:03:28,850 --> 00:03:27,840
of John wide varieties of subjects and

79
00:03:31,730 --> 00:03:28,860
we're looking at every single

80
00:03:34,130 --> 00:03:31,740
possibility so surely liquid water isn't

81
00:03:37,310 --> 00:03:34,140
the only real thing that we one would

82
00:03:38,780 --> 00:03:37,320
need right i mean there is that is that

83
00:03:40,970 --> 00:03:38,790
the defining characteristic of a

84
00:03:43,340 --> 00:03:40,980
habitable place a place where life can

85
00:03:46,700 --> 00:03:43,350
exist is that is that the only thing you

86
00:03:48,380 --> 00:03:46,710
guys are looking at well I can I can

87
00:03:50,600 --> 00:03:48,390
jump in here a little bit that's the

88
00:03:52,430 --> 00:03:50,610

classic definition but of course when

89
00:03:54,650 --> 00:03:52,440
you think about it that is very earth

90
00:03:57,020 --> 00:03:54,660
centric and of course we're looking at

91
00:03:58,910 --> 00:03:57,030
Mars to see if it is habitable or was

92
00:04:01,820 --> 00:03:58,920
habitable and it's thought that it did

93
00:04:03,590 --> 00:04:01,830
have water now of course the star can

94
00:04:05,600 --> 00:04:03,600
change the parent star like we have our

95
00:04:07,640 --> 00:04:05,610
Sun it changes very slowly there are

96
00:04:09,830 --> 00:04:07,650
other stars that change more rapidly and

97
00:04:12,560 --> 00:04:09,840
there are stars that change more slowly

98
00:04:15,500 --> 00:04:12,570
in their lifetimes so you're right the

99
00:04:17,660 --> 00:04:15,510
habitability can change so for a star

100
00:04:20,360 --> 00:04:17,670
that lives very fast there might be a

101
00:04:22,580 --> 00:04:20,370
region that is what fits our definition

102
00:04:24,860 --> 00:04:22,590
of habitable but because the star

103
00:04:27,200 --> 00:04:24,870
changes it brightness and energy so fast

104
00:04:27,950 --> 00:04:27,210
there's no chance that life will evolve

105
00:04:31,760 --> 00:04:27,960
and then there

106
00:04:34,279 --> 00:04:31,770
our other stars planets possibly around

107
00:04:36,740 --> 00:04:34,289
stars that take a very long time and are

108
00:04:41,779 --> 00:04:36,750
very stable and there's lots of chances

109
00:04:43,700 --> 00:04:41,789
that they could have a have area so for

110
00:04:46,490 --> 00:04:43,710
a moment in time the fact that a planet

111
00:04:49,219 --> 00:04:46,500
might be habitable does not mean okay

112
00:04:51,020 --> 00:04:49,229
now life is going to form for sure but

113
00:04:52,640 --> 00:04:51,030

it's a starting place it's yeah it's

114
00:04:54,409 --> 00:04:52,650
it's a starting place but it was as I

115
00:04:55,400 --> 00:04:54,419
look at the at the talks of some of

116
00:04:58,029 --> 00:04:55,410
these things that people were given

117
00:05:00,200 --> 00:04:58,039
there's one there was one on whether a

118
00:05:02,390 --> 00:05:00,210
series the dwarf planet ceres is

119
00:05:04,490 --> 00:05:02,400
habitable and you know there's talking

120
00:05:06,620 --> 00:05:04,500
you know and in Ava's talk was also

121
00:05:08,870 --> 00:05:06,630
about in which we're going to get to it

122
00:05:11,689 --> 00:05:08,880
here in a little bit more detail even

123
00:05:14,930 --> 00:05:11,699
about what is the survivability of I

124
00:05:16,400 --> 00:05:14,940
mean of going through a main sequence

125
00:05:18,439 --> 00:05:16,410
when when the star leaves the main

126
00:05:20,060 --> 00:05:18,449
sequence becomes a red giant what's the

127
00:05:22,310 --> 00:05:20,070
survivability of that and is there any

128
00:05:24,409 --> 00:05:22,320
chance for them to come back so we're

129
00:05:29,140 --> 00:05:24,419
looking way beyond liquid water here and

130
00:05:31,670 --> 00:05:29,150
so it's a really importance of I think

131
00:05:33,200 --> 00:05:31,680
in-depth look at this whole concept

132
00:05:35,089 --> 00:05:33,210
because they're really one of the things

133
00:05:39,200 --> 00:05:35,099
that I always get when I talk to people

134
00:05:40,760 --> 00:05:39,210
or do we do stories on exoplanets is why

135
00:05:42,800 --> 00:05:40,770
are we always so concerned about liquid

136
00:05:44,899 --> 00:05:42,810
water why can't you have like a sulfuric

137
00:05:46,939 --> 00:05:44,909
acid oceans or a Venus like place with

138
00:05:50,719 --> 00:05:46,949

with life could isn't it possible well

139
00:05:53,120 --> 00:05:50,729
sure it is but you know is it uh is it

140
00:05:54,469 --> 00:05:53,130
likely and when we know what is likely

141
00:05:57,740 --> 00:05:54,479
is the fact that we start with earth

142
00:05:58,850 --> 00:05:57,750
earth that's our one data point so even

143
00:06:00,550 --> 00:05:58,860
let me get you into this conversation

144
00:06:03,260 --> 00:06:00,560
what do you think of this idea of

145
00:06:06,740 --> 00:06:03,270
habitability in general do you think for

146
00:06:08,899 --> 00:06:06,750
example that the earth is typical are we

147
00:06:11,510 --> 00:06:08,909
are there a lot of us are there are a

148
00:06:13,189 --> 00:06:11,520
lot of planets like ours out there well

149
00:06:14,600 --> 00:06:13,199
in fact it is one of the most important

150
00:06:16,610 --> 00:06:14,610
parameters that we are trying to

151
00:06:18,680 --> 00:06:16,620
determine what is the percentage of

152
00:06:21,770 --> 00:06:18,690
planets out I mean of stars out there

153
00:06:26,719 --> 00:06:21,780
that have planets like Earth at the

154
00:06:28,700 --> 00:06:26,729
right distance and thus that's a very

155
00:06:30,980 --> 00:06:28,710
important question to answer because

156
00:06:33,140 --> 00:06:30,990
once we have this number we can assess

157
00:06:36,260 --> 00:06:33,150
what is the percentage of stars out

158
00:06:37,820 --> 00:06:36,270
there am I have at least a planet with

159
00:06:39,709 --> 00:06:37,830
the right conditions at the right

160
00:06:41,030 --> 00:06:39,719
distance in order to be able to host

161
00:06:43,550 --> 00:06:41,040
life

162
00:06:46,310 --> 00:06:43,560
as you mentioned yes we we look into

163
00:06:47,630 --> 00:06:46,320

liquid water because this is what we

164
00:06:50,480 --> 00:06:47,640
know but there might be other

165
00:06:52,220 --> 00:06:50,490
disciplines that are good for life the

166
00:06:54,950 --> 00:06:52,230
good thing about water is that it stands

167
00:06:57,320 --> 00:06:54,960
a broad range of conditions I mean we

168
00:06:59,870 --> 00:06:57,330
have more than 100 degrees between the

169
00:07:01,790 --> 00:06:59,880
point where the water freezes to the

170
00:07:04,430 --> 00:07:01,800
point where water gets evaporated and

171
00:07:07,190 --> 00:07:04,440
that's good for life a other forms of

172
00:07:10,850 --> 00:07:07,200
light my assists for example in a we say

173
00:07:12,890 --> 00:07:10,860
kind of this orbit but that would be

174
00:07:15,620 --> 00:07:12,900
hard to look for at me we have to start

175
00:07:20,030 --> 00:07:15,630
with the basic things and build up it

176
00:07:23,150 --> 00:07:20,040
slowly from there okay so you're you

177
00:07:24,770 --> 00:07:23,160
guys in your talk this afternoon I saw

178
00:07:26,210 --> 00:07:24,780
that you had a lot of references to work

179
00:07:29,440 --> 00:07:26,220
that you had done with Mario so

180
00:07:32,150 --> 00:07:29,450
presumably you guys have looked into

181
00:07:34,850 --> 00:07:32,160
this research of habitability and post

182
00:07:36,950 --> 00:07:34,860
main-sequence stars before so let's

183
00:07:39,290 --> 00:07:36,960
let's go into that a little bit your

184
00:07:43,280 --> 00:07:39,300
talk was called all our post

185
00:07:47,300 --> 00:07:43,290
main-sequence planets doomed and you

186
00:07:49,450 --> 00:07:47,310
were lookin by that what is a post main

187
00:07:53,390 --> 00:07:49,460
sequence star can you describe it for us

188
00:07:56,330 --> 00:07:53,400

it just as you know I mean we are

189
00:07:59,810 --> 00:07:56,340
orbiting a star that is burning burning

190
00:08:02,690 --> 00:07:59,820
hydrogen in the core but they start will

191
00:08:04,700 --> 00:08:02,700
eventually run out of hydrogen and as

192
00:08:08,360 --> 00:08:04,710
soon as that happens he will move into a

193
00:08:10,160 --> 00:08:08,370
different evolutionary stage a for a

194
00:08:12,170 --> 00:08:10,170
study in order to fight gravity has two

195
00:08:15,290 --> 00:08:12,180
persons in either in the cold in a shell

196
00:08:18,410 --> 00:08:15,300
outside of the outside of the core the

197
00:08:22,670 --> 00:08:18,420
rest nuclear fuel that the star like the

198
00:08:25,220 --> 00:08:22,680
Sun can burn is helium and that's it it

199
00:08:28,010 --> 00:08:25,230
cannot burn anything else so we talked

200
00:08:30,380 --> 00:08:28,020
about its master or well yes because of

201
00:08:33,580 --> 00:08:30,390
his mass if it were a more massive study

202
00:08:37,040 --> 00:08:33,590
will be able to burn much much higher

203
00:08:39,740 --> 00:08:37,050
element but I star like the Sun you will

204
00:08:42,500 --> 00:08:39,750
stop after helium you will be the carbon

205
00:08:45,050 --> 00:08:42,510
oxygen core and it will have the

206
00:08:47,930 --> 00:08:45,060
envelope removed by processes like winds

207
00:08:50,540 --> 00:08:47,940
and this is exactly what we mean by a

208
00:08:53,270 --> 00:08:50,550
post main sequence star am in sequence

209
00:08:54,530 --> 00:08:53,280
main sequence star a star is a star that

210
00:08:58,040 --> 00:08:54,540
is burning hi

211
00:08:59,900 --> 00:08:58,050
it was many sequences that he has run

212
00:09:07,129 --> 00:08:59,910
out of hydrogen in the core and it goes

213
00:09:09,110 --> 00:09:07,139

through a very let's say not not stable

214
00:09:11,389 --> 00:09:09,120
phases of evolution yeah it starts to

215
00:09:13,400 --> 00:09:11,399
get big right it starts to expand and

216
00:09:15,350 --> 00:09:13,410
then get and get larger right that when

217
00:09:18,800 --> 00:09:15,360
it when it turns into a red giant yes

218
00:09:22,370 --> 00:09:18,810
yes okay so I was just going to say main

219
00:09:24,680 --> 00:09:22,380
sequence refers to the majority of the

220
00:09:26,389 --> 00:09:24,690
time the star spends in a stable state

221
00:09:28,550 --> 00:09:26,399
and we call that main sequence for

222
00:09:31,629 --> 00:09:28,560
different stars of different masses the

223
00:09:34,730 --> 00:09:31,639
amount of time that occurs is different

224
00:09:37,579 --> 00:09:34,740
luckily for us that for the Sun it's a

225
00:09:40,999 --> 00:09:37,589
long time and then post main sequence is

226
00:09:42,650 --> 00:09:41,009
as Eva said now you've got problems in

227
00:09:44,720 --> 00:09:42,660
the core you've exhausted some of the

228
00:09:46,970 --> 00:09:44,730
fuel and now the structure of the star

229
00:09:49,129 --> 00:09:46,980
is trying to readjust to its

230
00:09:50,930 --> 00:09:49,139
circumstance that's got gravity pushing

231
00:09:54,410 --> 00:09:50,940
in and energy putting pushing out and

232
00:09:57,860 --> 00:09:54,420
that isn't so good for a planet that is

233
00:10:00,199 --> 00:09:57,870
out in orbit around that star okay so

234
00:10:02,509 --> 00:10:00,209
Mario did you do some work with did you

235
00:10:03,980 --> 00:10:02,519
Ava work together earlier on some of

236
00:10:06,710 --> 00:10:03,990
these questions as well I saw your name

237
00:10:09,439 --> 00:10:06,720
on a lot of slides yeah we we started

238
00:10:12,470 --> 00:10:09,449

working on this I don't know around two

239
00:10:15,319 --> 00:10:12,480
thousand five six I think maybe

240
00:10:18,139 --> 00:10:15,329
published our first work in 2007 or

241
00:10:20,930 --> 00:10:18,149
thereabout and then published a few more

242
00:10:24,620 --> 00:10:20,940
works following that so so the idea is

243
00:10:28,069 --> 00:10:24,630
very simple since we now know that most

244
00:10:30,019 --> 00:10:28,079
stars have planets around them the

245
00:10:33,350 --> 00:10:30,029
question is what happens to these

246
00:10:36,559 --> 00:10:33,360
planets as the star as we said you know

247
00:10:39,620 --> 00:10:36,569
exhausts its its hydrogen and a star

248
00:10:42,490 --> 00:10:39,630
like the Sun is going to increase in

249
00:10:45,259 --> 00:10:42,500
radius you know x factor of hundreds

250
00:10:47,420 --> 00:10:45,269
when when it becomes a you know a red

251
00:10:51,019 --> 00:10:47,430
giant star I'll pass to the orbit of

252
00:10:54,199 --> 00:10:51,029
Earth presumable well actually the earth

253
00:10:57,829 --> 00:10:54,209
turns out to be the most difficult thing

254
00:11:01,670 --> 00:10:57,839
to calculate if it while it's true that

255
00:11:04,069 --> 00:11:01,680
the the Sun can out past the orbit the

256
00:11:06,829 --> 00:11:04,079
current orbit of Earth earth itself

257
00:11:08,180 --> 00:11:06,839
might move a little bit outwards by that

258
00:11:10,850 --> 00:11:08,190
time oh that's right

259
00:11:12,620 --> 00:11:10,860
course yes so so it you know so it's

260
00:11:15,710 --> 00:11:12,630
it's a touch and go what will actually

261
00:11:17,600 --> 00:11:15,720
happen to earth but but let's talk more

262
00:11:19,940 --> 00:11:17,610
generally about many of these planets

263
00:11:22,670 --> 00:11:19,950

that are in there so now you have this

264
00:11:25,490 --> 00:11:22,680
giant star and you have a planet that

265
00:11:27,770 --> 00:11:25,500
you know okay was not directly engulfed

266
00:11:30,280 --> 00:11:27,780
in it it was just you know was left

267
00:11:33,590 --> 00:11:30,290
there but what happens at that point

268
00:11:37,430 --> 00:11:33,600
according to our calculations is that

269
00:11:40,850 --> 00:11:37,440
the the planet raises tides on the star

270
00:11:45,130 --> 00:11:40,860
just like the moon raises tides on on

271
00:11:48,110 --> 00:11:45,140
the earth and as it raises those tides

272
00:11:50,990 --> 00:11:48,120
the orbit starts to dissipate and the

273
00:11:53,690 --> 00:11:51,000
planet starts to move inward and we

274
00:11:56,060 --> 00:11:53,700
wanted to know which planets would

275
00:11:58,550 --> 00:11:56,070
actually be eventually engulfed by the

276
00:12:02,240 --> 00:11:58,560
star which planets would manage to

277
00:12:04,790 --> 00:12:02,250
survive and and so on so for example the

278
00:12:07,070 --> 00:12:04,800
earth really turns out to be a dep

279
00:12:09,080 --> 00:12:07,080
touch-and-go place where some

280
00:12:11,690 --> 00:12:09,090
calculations show that it will be

281
00:12:14,990 --> 00:12:11,700
eventually engulf some show that it may

282
00:12:17,120 --> 00:12:15,000
just barely survived now planets of

283
00:12:20,720 --> 00:12:17,130
course that are farther than where the

284
00:12:22,880 --> 00:12:20,730
earth is now will survive but even if

285
00:12:25,700 --> 00:12:22,890
they survive in terms of you know that

286
00:12:28,010 --> 00:12:25,710
physically they are still there that

287
00:12:30,680 --> 00:12:28,020
doesn't mean that life on them can

288
00:12:33,350 --> 00:12:30,690

survive drivin for example the earth

289
00:12:36,250 --> 00:12:33,360
will be scorched I mean even if it's not

290
00:12:39,800 --> 00:12:36,260
enough it will be totally scorched so

291
00:12:42,200 --> 00:12:39,810
there there are all these deep questions

292
00:12:44,720 --> 00:12:42,210
as to what happens to if there is life

293
00:12:48,710 --> 00:12:44,730
on any kinds of these planets what

294
00:12:50,930 --> 00:12:48,720
happens to them is their stars evolve so

295
00:12:52,940 --> 00:12:50,940
Ava in your talk you actually address

296
00:12:54,770 --> 00:12:52,950
that your talk was split up into two

297
00:12:57,050 --> 00:12:54,780
main parts as I understood it you were

298
00:13:00,590 --> 00:12:57,060
trying to answer the question would life

299
00:13:02,960 --> 00:13:00,600
have to endure after this what Mario

300
00:13:05,420 --> 00:13:02,970
just happened what would life have to go

301
00:13:07,430 --> 00:13:05,430
through describe it presumably if it

302
00:13:09,260 --> 00:13:07,440
even could and the second question were

303
00:13:13,130 --> 00:13:09,270
asking is are there any suitable

304
00:13:16,040 --> 00:13:13,140
conditions that might form after the

305
00:13:19,160 --> 00:13:16,050
goat the red giant phase that might be

306
00:13:21,410 --> 00:13:19,170
my give life a second chance to start up

307
00:13:22,040 --> 00:13:21,420
on earth and you can you comment on that

308
00:13:23,509 --> 00:13:22,050
a little bit

309
00:13:28,340 --> 00:13:23,519
especially to the first point what would

310
00:13:30,470 --> 00:13:28,350
life have to endure to get to survive

311
00:13:33,199 --> 00:13:30,480
the red giant phase if it even could and

312
00:13:35,329 --> 00:13:33,209
do you think it could well first of all

313
00:13:38,240 --> 00:13:35,339

before even the star leaves the main

314
00:13:41,660 --> 00:13:38,250
sequence this stage of evolution where

315
00:13:43,340 --> 00:13:41,670
the Sun is stable the luminosity of the

316
00:13:45,410 --> 00:13:43,350
Sun will increase I mean the energy that

317
00:13:47,690 --> 00:13:45,420
the Sun will emit per second is going to

318
00:13:52,220 --> 00:13:47,700
increase and these guys got brighter on

319
00:13:54,410 --> 00:13:52,230
earth exactly and that will have I mean

320
00:13:56,930 --> 00:13:54,420
it's not clear where the weather at the

321
00:13:59,690 --> 00:13:56,940
atmosphere will be i were to adjust to

322
00:14:03,440 --> 00:13:59,700
the changes provided by the increasing

323
00:14:05,750 --> 00:14:03,450
luminosity of the Sun over the over the

324
00:14:07,400 --> 00:14:05,760
time span that will happen but most

325
00:14:08,810 --> 00:14:07,410
likely not I mean most likely the

326
00:14:10,310 --> 00:14:08,820
atmosphere will get it because the

327
00:14:12,560 --> 00:14:10,320
stellar the solar wind will be also

328
00:14:16,250 --> 00:14:12,570
increased quite a bit tues i right hey

329
00:14:18,110 --> 00:14:16,260
yes yes in the radiation but we have the

330
00:14:19,730 --> 00:14:18,120
magnetic field that brought from the air

331
00:14:22,100 --> 00:14:19,740
that will protect it from the solar wind

332
00:14:24,380 --> 00:14:22,110
so the solar wind is not such a big

333
00:14:27,740 --> 00:14:24,390
problem is increasing the energy of the

334
00:14:30,680 --> 00:14:27,750
emitted by the Sun that will will make

335
00:14:32,300 --> 00:14:30,690
this planet a very hot place and we will

336
00:14:35,000 --> 00:14:32,310
have probably a runaway of red light

337
00:14:37,340 --> 00:14:35,010
like the one that happened in India nose

338
00:14:38,930 --> 00:14:37,350

and got rid of the atmosphere so that

339
00:14:42,139 --> 00:14:38,940
will be the first thing before even the

340
00:14:44,389 --> 00:14:42,149
Sun gets bigger the design with a start

341
00:14:47,690 --> 00:14:44,399
to get bigger in radios so we are going

342
00:14:50,750 --> 00:14:47,700
to have a planet that in my move

343
00:14:52,130 --> 00:14:50,760
outwards a little bit but we have the

344
00:14:55,400 --> 00:14:52,140
surface of the sun de will be

345
00:14:56,930 --> 00:14:55,410
approaching us as the Sun evolves so we

346
00:15:01,130 --> 00:14:56,940
are going to get very close to the

347
00:15:04,130 --> 00:15:01,140
surface of a sudden principle that that

348
00:15:07,550 --> 00:15:04,140
is another of the of the things that

349
00:15:09,860 --> 00:15:07,560
life will have to endure if it has

350
00:15:14,000 --> 00:15:09,870
already managed to survive increase in

351
00:15:16,400 --> 00:15:14,010
luminosity a infrared reason luminosity

352
00:15:18,380 --> 00:15:16,410
and we're gonna get closer to the to the

353
00:15:21,769 --> 00:15:18,390
star or the stars going closer to us

354
00:15:24,680 --> 00:15:21,779
yeah we might get that close that we

355
00:15:27,650 --> 00:15:24,690
might even get inside of the office and

356
00:15:29,449 --> 00:15:27,660
and if we get inside of the Sun forget

357
00:15:31,550 --> 00:15:29,459
it I mean the planet will eventually a

358
00:15:34,490 --> 00:15:31,560
spiral in very quickly and it will merge

359
00:15:35,570 --> 00:15:34,500
with the core of the star so that will

360
00:15:41,020 --> 00:15:35,580
be

361
00:15:47,450 --> 00:15:45,230
yeah so if the planet managed to survive

362
00:15:50,390 --> 00:15:47,460
this face then it would be a very stable

363
00:15:53,660 --> 00:15:50,400

phase following that of helium burning

364
00:15:56,720 --> 00:15:53,670
in the core in which if life had managed

365
00:15:59,690 --> 00:15:56,730
to survive somehow and he might be able

366
00:16:03,080 --> 00:15:59,700
to do have a second chance to to develop

367
00:16:05,330 --> 00:16:03,090
for to enjoy a few more he got years

368
00:16:07,790 --> 00:16:05,340
it's better to move before it's too late

369
00:16:09,890 --> 00:16:07,800
yeah yeah yeah well we're luckily we've

370
00:16:11,480 --> 00:16:09,900
got some time when twin let's just go

371
00:16:13,010 --> 00:16:11,490
ahead and say when you're expected when

372
00:16:15,740 --> 00:16:13,020
is this expected to happen with that

373
00:16:18,200 --> 00:16:15,750
with our son in about five billion years

374
00:16:20,330 --> 00:16:18,210
oh good so all right so there's no

375
00:16:21,830 --> 00:16:20,340
immediate cause for alarm at least right

376
00:16:24,890 --> 00:16:21,840
now but the fact that you're looking at

377
00:16:26,840 --> 00:16:24,900
this and in a in a bigger picture is

378
00:16:28,610 --> 00:16:26,850
really fascinating to me I mean you're

379
00:16:31,190 --> 00:16:28,620
looking at not just you know obviously I

380
00:16:33,380 --> 00:16:31,200
like to bring it home because earth is a

381
00:16:36,020 --> 00:16:33,390
typical thing that we can you know

382
00:16:37,940 --> 00:16:36,030
visualize and so to see how this how our

383
00:16:41,120 --> 00:16:37,950
Sun evolves and what might happen to

384
00:16:45,020 --> 00:16:41,130
life here is an important one but in

385
00:16:47,120 --> 00:16:45,030
your talk uh use you use a really scary

386
00:16:55,190 --> 00:16:47,130
term cold I remember laughing when i saw

387
00:16:57,230 --> 00:16:55,200
it planet evaporation rates um yikes so

388
00:16:59,330 --> 00:16:57,240

why don't you tell it so what so what

389
00:17:02,170 --> 00:16:59,340
does that mean the planet of a these are

390
00:17:04,790 --> 00:17:02,180
when planets just simply don't survive

391
00:17:06,890 --> 00:17:04,800
yes this is a different phase of

392
00:17:09,500 --> 00:17:06,900
evolution that a planet will have to

393
00:17:11,660 --> 00:17:09,510
endure after the postman sequencing it's

394
00:17:16,340 --> 00:17:11,670
the planetary nebula phase in which we

395
00:17:20,150 --> 00:17:16,350
have a very huge flags of radiation that

396
00:17:22,610 --> 00:17:20,160
is neutral eye on it so something I mean

397
00:17:24,680 --> 00:17:22,620
we have the ozone layer now protect us

398
00:17:26,870 --> 00:17:24,690
from protecting us from the ultraviolet

399
00:17:30,170 --> 00:17:26,880
radiation from the Sun imagine a

400
00:17:33,290 --> 00:17:30,180
radiation that is much much much higher

401
00:17:36,140 --> 00:17:33,300
orders of magnitude higher in a star

402
00:17:39,770 --> 00:17:36,150
that is has a wolf of the main sequence

403
00:17:42,110 --> 00:17:39,780
and that this radiation has so much

404
00:17:44,600 --> 00:17:42,120
energy that literally evaporates the

405
00:17:46,640 --> 00:17:44,610
surface of a planet of a gas planet and

406
00:17:49,460 --> 00:17:46,650
this is the controlling super late the

407
00:17:52,730 --> 00:17:49,470
ultra pile energy front of her napkin

408
00:17:54,409 --> 00:17:52,740
gave a black row can you um little

409
00:17:58,820 --> 00:17:54,419
background on a planetary nebula buh

410
00:18:00,500 --> 00:17:58,830
will she talk about that I could

411
00:18:03,140 --> 00:18:00,510
understand the question story you're

412
00:18:06,380 --> 00:18:03,150
breaking up Tony you've been breaking up

413
00:18:08,450 --> 00:18:06,390

yeah we could hear the question can I

414
00:18:12,169 --> 00:18:08,460
ask a question while we figure that out

415
00:18:15,470 --> 00:18:12,179
my question to Eva and Mario is that I

416
00:18:17,299 --> 00:18:15,480
know so you have this phase where the

417
00:18:19,250 --> 00:18:17,309
surface of you know the the Sun is

418
00:18:20,840 --> 00:18:19,260
getting bigger stars like the Sun is

419
00:18:24,799 --> 00:18:20,850
getting bigger and then you talk about

420
00:18:27,590 --> 00:18:24,809
okay that may be the demise of Earth but

421
00:18:29,690 --> 00:18:27,600
what about like moons and planets that

422
00:18:32,000 --> 00:18:29,700
are further out that may have water on

423
00:18:34,460 --> 00:18:32,010
them what happens to them because

424
00:18:35,720 --> 00:18:34,470
presumably they get warmer and I know

425
00:18:37,789 --> 00:18:35,730
there are some people that are

426
00:18:40,970 --> 00:18:37,799
interested in you know what could happen

427
00:18:42,649 --> 00:18:40,980
to a moon that has ice on it now will it

428
00:18:45,080 --> 00:18:42,659
have water and it will it be in that

429
00:18:50,899 --> 00:18:45,090
state long enough for even the tiniest

430
00:18:54,080 --> 00:18:50,909
microbe to form well as the Santa volts

431
00:18:56,330 --> 00:18:54,090
the abbot ability so we'll move outwards

432
00:18:59,720 --> 00:18:56,340
so it will reach the region where we

433
00:19:02,810 --> 00:18:59,730
don't have planned I mean we can't have

434
00:19:05,180 --> 00:19:02,820
planets with moons out there where what

435
00:19:07,070 --> 00:19:05,190
life can be sustainable you have to keep

436
00:19:09,200 --> 00:19:07,080
in mind that the faces of evolution

437
00:19:12,529 --> 00:19:09,210
after the main sequence are shorter so

438
00:19:16,970 --> 00:19:12,539

we are going to talk about of the order

439
00:19:21,680 --> 00:19:16,980
of a billion years one being yeah so I

440
00:19:25,520 --> 00:19:21,690
mean that's not long enough probably not

441
00:19:29,870 --> 00:19:25,530
you know maybe for microbes yes but for

442
00:19:31,960 --> 00:19:29,880
elephants probably all in my back eyes

443
00:19:34,159 --> 00:19:31,970
can you yeah yeah yeah we hear you

444
00:19:36,049 --> 00:19:34,169
alright what I wanted it what I wanted

445
00:19:37,460 --> 00:19:36,059
to get into right there was planetary

446
00:19:39,039 --> 00:19:37,470
nebula I wanted to go back to that idea

447
00:19:42,710 --> 00:19:39,049
and I wanted Carol to kind of explain

448
00:19:44,270 --> 00:19:42,720
how the earth gets over how the Sun gets

449
00:19:45,350 --> 00:19:44,280
to a planetary nebula just give this

450
00:19:48,409 --> 00:19:45,360
whole background on in case people don't

451
00:19:52,159 --> 00:19:48,419
know what that is so so just about the

452
00:19:54,350 --> 00:19:52,169
term you know astronomers are you know

453
00:19:55,669 --> 00:19:54,360
when they look through the telescope and

454
00:19:57,770 --> 00:19:55,679
they see something and it reminds them

455
00:19:59,899 --> 00:19:57,780
of something else a word comes out of

456
00:20:03,080 --> 00:19:59,909
their mouth and it may not happy have

457
00:20:05,420 --> 00:20:03,090
Astrophysical significance so planetary

458
00:20:07,370 --> 00:20:05,430
were thought to be when they they were

459
00:20:09,020 --> 00:20:07,380
first seen through a telescope so a star

460
00:20:11,000 --> 00:20:09,030
with some kind of planetary system

461
00:20:13,160 --> 00:20:11,010
around it well it turns out there

462
00:20:15,500 --> 00:20:13,170
actually nebula and they really have

463
00:20:16,880 --> 00:20:15,510

nothing to do with planets or probably

464
00:20:19,130 --> 00:20:16,890
don't have mean that's not their main

465
00:20:22,730 --> 00:20:19,140
function actually Mario is an expert on

466
00:20:24,230 --> 00:20:22,740
this but anyway the idea is as they've

467
00:20:26,030 --> 00:20:24,240
been discussing even Mario been

468
00:20:28,760 --> 00:20:26,040
discussing the core of the star

469
00:20:30,980 --> 00:20:28,770
collapses it starts to push its outer

470
00:20:34,850 --> 00:20:30,990
atmosphere out it gets bigger it's

471
00:20:37,660 --> 00:20:34,860
pumping out energy at some point it may

472
00:20:40,430 --> 00:20:37,670
have a more dramatic structure

473
00:20:43,400 --> 00:20:40,440
rearrangement which will force the outer

474
00:20:46,220 --> 00:20:43,410
part a lot of them material on the outer

475
00:20:48,680 --> 00:20:46,230
part of the star it won't explode per se

476
00:20:50,780 --> 00:20:48,690
but it will push a lot of material out

477
00:20:53,750 --> 00:20:50,790
and we used to think that was a nice

478
00:20:56,060 --> 00:20:53,760
little gentle process and it's a nice

479
00:20:57,920 --> 00:20:56,070
fear achill nebula well it turns out

480
00:21:00,470 --> 00:20:57,930
with Hubble we found out that the

481
00:21:02,780 --> 00:21:00,480
structures of planetary nebula are quite

482
00:21:06,050 --> 00:21:02,790
complicated and that process of

483
00:21:08,210 --> 00:21:06,060
readjusting the structure is complicated

484
00:21:10,280 --> 00:21:08,220
but gives rise to I think some of the

485
00:21:12,740 --> 00:21:10,290
most beautiful nebula we have imaged

486
00:21:15,830 --> 00:21:12,750
with Hubble so Mario and Eva can take it

487
00:21:17,930 --> 00:21:15,840
from there yeah let me just add that you

488
00:21:20,420 --> 00:21:17,940

know just do this last point that that

489
00:21:23,450 --> 00:21:20,430
Carol made it you know if you look at

490
00:21:26,090 --> 00:21:23,460
some of the most fantastic images that

491
00:21:28,910 --> 00:21:26,100
Hubble has taken they are of planetary

492
00:21:31,850 --> 00:21:28,920
nebulae because what happens is this as

493
00:21:35,600 --> 00:21:31,860
this outer layers are pushed into space

494
00:21:37,670 --> 00:21:35,610
you expose this hot core that ever was

495
00:21:40,970 --> 00:21:37,680
talking about which emits this

496
00:21:44,720 --> 00:21:40,980
ultraviolet radiation and that really

497
00:21:47,480 --> 00:21:44,730
hits all this gas that was ejected and

498
00:21:49,940 --> 00:21:47,490
it causes it to fluoresce and so you see

499
00:21:52,940 --> 00:21:49,950
all these fantastic colors in it and

500
00:21:56,300 --> 00:21:52,950
really those are truly breathtaking

501
00:21:58,070 --> 00:21:56,310
images of these planetary nebulae and

502
00:22:00,230 --> 00:21:58,080
they are all different I mean you know

503
00:22:02,900 --> 00:22:00,240
like snowflakes each one of them looks

504
00:22:04,070 --> 00:22:02,910
differently a very famous example for

505
00:22:05,360 --> 00:22:04,080
those of you who want to know is the

506
00:22:07,640 --> 00:22:05,370
ring nebula that's a very famous

507
00:22:10,370 --> 00:22:07,650
planetary nebulas like a smoke ring in

508
00:22:11,810 --> 00:22:10,380
space in Mali that that's the one I

509
00:22:13,040 --> 00:22:11,820
learned about and forth I always say I

510
00:22:16,460 --> 00:22:13,050
learned about that in fourth grade and

511
00:22:18,080 --> 00:22:16,470
everybody thought it was a nice uniform

512
00:22:19,580 --> 00:22:18,090
as you said smoke ring but actually when

513
00:22:21,740 --> 00:22:19,590

you look at it in the Hubble images in

514
00:22:26,240 --> 00:22:21,750
detail it has all kinds of very

515
00:22:29,930 --> 00:22:26,250
interesting structures yes I realize so

516
00:22:34,010 --> 00:22:29,940
Ava in your talk on this unsub like you

517
00:22:38,470 --> 00:22:34,020
said that the bad thing is that has 10

518
00:22:43,190 --> 00:22:38,480
memory in them but don't he's funny you

519
00:22:46,730 --> 00:22:43,200
got again I didn't quite get the sense

520
00:22:49,520 --> 00:22:46,740
of your question okay so in your time i

521
00:22:52,130 --> 00:22:49,530
am i okay now yes you're in your talk

522
00:22:54,980 --> 00:22:52,140
you with the planetary nebula you said

523
00:22:57,620 --> 00:22:54,990
the bad thing is that planets tend to

524
00:22:59,299 --> 00:22:57,630
evaporate inside of them but there's a

525
00:23:01,669 --> 00:22:59,309
good side to it and the good side is

526
00:23:04,310 --> 00:23:01,679
that there's also lots of really good

527
00:23:06,580 --> 00:23:04,320
complex molecules inside these things do

528
00:23:09,049 --> 00:23:06,590
you think that for planets that survive

529
00:23:10,310 --> 00:23:09,059
that don't manage to evaporate there

530
00:23:13,549 --> 00:23:10,320
might be something there for them to

531
00:23:15,380 --> 00:23:13,559
work with yeah I think I mean we're made

532
00:23:17,720 --> 00:23:15,390
of carbon after all and one of the main

533
00:23:19,640 --> 00:23:17,730
producers of carbon in space are the

534
00:23:22,399 --> 00:23:19,650
stars like the Sun that evolved into the

535
00:23:25,880 --> 00:23:22,409
planetary nebula state so the fact that

536
00:23:29,029 --> 00:23:25,890
we have carbon producers building big

537
00:23:31,820 --> 00:23:29,039
molecules of as I mentioned it was a

538
00:23:34,610 --> 00:23:31,830

carbon 60 fullerene molecules out there

539
00:23:37,789 --> 00:23:34,620
I think it's a good news for for life

540
00:23:39,950 --> 00:23:37,799
and only material would have we are made

541
00:23:42,700 --> 00:23:39,960
of fatty and kind came from the interior

542
00:23:46,580 --> 00:23:42,710
of stars and these stars are literally

543
00:23:48,560 --> 00:23:46,590
bringing the vibrance of nucleosynthesis

544
00:23:51,620 --> 00:23:48,570
into the interstellar million again

545
00:23:56,480 --> 00:23:51,630
we're a generation of stars and planets

546
00:23:59,090 --> 00:23:56,490
is formed so if we have already complex

547
00:24:01,580 --> 00:23:59,100
material over there and we have a chance

548
00:24:04,039 --> 00:24:01,590
in order to build planets around these

549
00:24:05,840 --> 00:24:04,049
systems that we don't have to wait for

550
00:24:07,850 --> 00:24:05,850
the next generation of start to build in

551
00:24:10,520 --> 00:24:07,860
a generation of planets I think that's

552
00:24:12,049 --> 00:24:10,530
that's good news for life well what

553
00:24:16,490 --> 00:24:12,059
about the water question though I mean

554
00:24:18,529 --> 00:24:16,500
the the the conditions inside these

555
00:24:20,720 --> 00:24:18,539
nebulae and even after that that phase

556
00:24:22,820 --> 00:24:20,730
are we going to get water back or is it

557
00:24:25,130 --> 00:24:22,830
is it gone forever does it survive how

558
00:24:27,770 --> 00:24:25,140
does it survive well not where it's very

559
00:24:30,230 --> 00:24:27,780
hard you will not get it to where it's

560
00:24:31,970 --> 00:24:30,240
very hot but but as we say then

561
00:24:34,820 --> 00:24:31,980
you know the habitable zone moves

562
00:24:37,190 --> 00:24:34,830
outwards is that star evolves and

563
00:24:39,169 --> 00:24:37,200

becomes more luminous and hotter so

564
00:24:43,000 --> 00:24:39,179
there will be some region which is

565
00:24:45,110 --> 00:24:43,010
farther out which could still have water

566
00:24:48,410 --> 00:24:45,120
okay and so what are we left with after

567
00:24:50,780 --> 00:24:48,420
this phase after the after the planetary

568
00:24:53,840 --> 00:24:50,790
nebula phase we're left with a white

569
00:24:56,870 --> 00:24:53,850
dwarf right so hopefully we've got a

570
00:24:58,549 --> 00:24:56,880
white dwarf star with some planets in a

571
00:25:02,450 --> 00:24:58,559
stable orbit that survived everything

572
00:25:04,669 --> 00:25:02,460
somewhere near a new habitable zone is

573
00:25:08,720 --> 00:25:04,679
there a time scale that is conducive to

574
00:25:10,850 --> 00:25:08,730
life reforming here it is a time scale

575
00:25:12,710 --> 00:25:10,860
if we are very close to the star and the

576
00:25:14,360 --> 00:25:12,720
problem is that is very hard to bring a

577
00:25:17,030 --> 00:25:14,370
planet that goes to the star at that

578
00:25:19,190 --> 00:25:17,040
point because as I mentioned in my talk

579
00:25:21,230 --> 00:25:19,200
every planet that we sped out of the

580
00:25:23,210 --> 00:25:21,240
systems are going to be very far away so

581
00:25:25,130 --> 00:25:23,220
we have to put to build a mechanism in

582
00:25:27,980 --> 00:25:25,140
order to throw a planet close to the

583
00:25:31,460 --> 00:25:27,990
white dwarf and that's a very unlikely

584
00:25:33,590 --> 00:25:31,470
process but it may happen I mean we know

585
00:25:37,700 --> 00:25:33,600
life is a very unlikely processor we are

586
00:25:39,320 --> 00:25:37,710
here so to keep in mind well that's a

587
00:25:41,900 --> 00:25:39,330
question isn't it that's one of the

588
00:25:46,640 --> 00:25:41,910

things I wanted to address in my opinion

589
00:25:49,460 --> 00:25:46,650
life is either incredibly easy to bring

590
00:25:51,200 --> 00:25:49,470
about or it's very very hard and there

591
00:25:54,140 --> 00:25:51,210
are all kinds of you know I've always

592
00:25:57,230 --> 00:25:54,150
wondered what does it take to go from a

593
00:26:01,130 --> 00:25:57,240
system with zero life no life whatsoever

594
00:26:02,750 --> 00:26:01,140
to having life like amino acids my form

595
00:26:05,419 --> 00:26:02,760
in an earlier that we might get all

596
00:26:08,000 --> 00:26:05,429
kinds of gases and primordial soups and

597
00:26:10,070 --> 00:26:08,010
everything that won't be alive so it one

598
00:26:12,440 --> 00:26:10,080
day we wake up and there's life in there

599
00:26:15,110 --> 00:26:12,450
that step going from something that's

600
00:26:19,010 --> 00:26:15,120
not alive to something that's live I

601
00:26:21,799 --> 00:26:19,020
want to know how hard that is so so that

602
00:26:24,070 --> 00:26:21,809
first step it appears to be at least

603
00:26:27,200 --> 00:26:24,080
from the one example we have on earth

604
00:26:29,930 --> 00:26:27,210
appears to be not that hard that very

605
00:26:32,480 --> 00:26:29,940
first step and the reason I say this is

606
00:26:35,840 --> 00:26:32,490
there are two reasons really one is that

607
00:26:38,090 --> 00:26:35,850
life on Earth appeared almost as soon as

608
00:26:40,520 --> 00:26:38,100
it could have appeared namely you know

609
00:26:42,620 --> 00:26:40,530
that the very very early Earth things

610
00:26:44,600 --> 00:26:42,630
were very hot there was a lot of boom

611
00:26:47,360 --> 00:26:44,610
argument and so on by all kinds of

612
00:26:50,600 --> 00:26:47,370
asteroids and meteors and whatnot and so

613
00:26:53,120 --> 00:26:50,610

on but as soon as you know the situation

614
00:26:56,420 --> 00:26:53,130
stabilized a little bit we find already

615
00:26:58,550 --> 00:26:56,430
signs to life so clearly on earth it

616
00:27:00,740 --> 00:26:58,560
didn't take too long for life to appear

617
00:27:04,790 --> 00:27:00,750
the second reason I say that first step

618
00:27:06,530 --> 00:27:04,800
may not be hard is that I have a friend

619
00:27:08,900 --> 00:27:06,540
Jack Shaw stuck with a Nobel laureate

620
00:27:13,130 --> 00:27:08,910
who works at Harvard in trying to

621
00:27:15,320 --> 00:27:13,140
produce life in the lab and the last

622
00:27:17,690 --> 00:27:15,330
time I asked him so how long do you

623
00:27:20,450 --> 00:27:17,700
think it will be before you actually can

624
00:27:24,410 --> 00:27:20,460
produce life in the lab and his answer

625
00:27:27,770 --> 00:27:24,420
was about five years so you know if you

626
00:27:30,500 --> 00:27:27,780
do yeah yeah so you if you can produce

627
00:27:33,710 --> 00:27:30,510
life in the lab it means it's really not

628
00:27:35,330 --> 00:27:33,720
that hard now again if you take a lesson

629
00:27:38,510 --> 00:27:35,340
from Earth and you should be very

630
00:27:42,860 --> 00:27:38,520
careful doing this because it is one

631
00:27:47,000 --> 00:27:42,870
example then the step to get from very

632
00:27:49,750 --> 00:27:47,010
primitive life to very complex life that

633
00:27:53,470 --> 00:27:49,760
actually took a long time on earth

634
00:27:57,470 --> 00:27:53,480
billions of years and also required all

635
00:28:00,800 --> 00:27:57,480
kinds of fine tunings and in you know

636
00:28:03,980 --> 00:28:00,810
chance events and so on so that may be

637
00:28:05,480 --> 00:28:03,990
the part that's really hard wow there's

638
00:28:07,280 --> 00:28:05,490

there's a hangout I need to have we need

639
00:28:08,660 --> 00:28:07,290
to get you and Seth together and talk

640
00:28:10,100 --> 00:28:08,670
about this more in depth at some point

641
00:28:13,820 --> 00:28:10,110
in the future that sounds like a great a

642
00:28:15,410 --> 00:28:13,830
great one okay so we're out of time but

643
00:28:18,230 --> 00:28:15,420
I want to get to one quick question uh

644
00:28:21,500 --> 00:28:18,240
Brian catnip on the Q&A app is asking

645
00:28:24,050 --> 00:28:21,510
can organisms survive off gases other

646
00:28:30,260 --> 00:28:24,060
than oxygen and co2 who wants to take

647
00:28:33,500 --> 00:28:30,270
that one well I mean yeah I'm a great

648
00:28:35,420 --> 00:28:33,510
expert on it I only know I own a little

649
00:28:37,880 --> 00:28:35,430
bit about this but there are actually

650
00:28:41,440 --> 00:28:37,890
there are quite a number of biologists

651
00:28:43,640 --> 00:28:41,450
who are working on these questions and

652
00:28:45,500 --> 00:28:43,650
there's there's another kind of

653
00:28:46,880 --> 00:28:45,510
survivability that they are interested

654
00:28:48,680 --> 00:28:46,890
in it's not so much the planet

655
00:28:51,100 --> 00:28:48,690
survivability they are interested in the

656
00:28:54,020 --> 00:28:51,110
survivability and adaptability of

657
00:28:56,210 --> 00:28:54,030
organisms and so there do seem to be

658
00:28:59,210 --> 00:28:56,220
some organisms that Canada

659
00:29:01,010 --> 00:28:59,220
adapt to what we would consider a very

660
00:29:03,799 --> 00:29:01,020
hostile living in environment but they

661
00:29:06,500 --> 00:29:03,809
are organisms they are not elephants is

662
00:29:09,380 --> 00:29:06,510
new files aren't they in the right

663
00:29:11,510 --> 00:29:09,390

Mentos as far as Mario Mario nima made

664
00:29:14,210 --> 00:29:11,520
no different but as far as I know there

665
00:29:16,700 --> 00:29:14,220
has not been any building blocks of life

666
00:29:20,260 --> 00:29:16,710
formed in one of those adverse

667
00:29:22,520 --> 00:29:20,270
environment environments but the biology

668
00:29:25,430 --> 00:29:22,530
biologists who are looking at something

669
00:29:30,820 --> 00:29:25,440
called extremophiles are studying

670
00:29:32,779 --> 00:29:30,830
whether life can a adapt or be survive

671
00:29:34,430 --> 00:29:32,789
conditions and that goes back a little

672
00:29:36,140 --> 00:29:34,440
bit to the question you asked you notice

673
00:29:38,899 --> 00:29:36,150
that these catastrophic events happen

674
00:29:41,450 --> 00:29:38,909
maybe in the outer solar system microbes

675
00:29:43,370 --> 00:29:41,460
form then they freeze or they get hot

676
00:29:45,380 --> 00:29:43,380
can they survive and then come back to

677
00:29:47,630 --> 00:29:45,390
life in it and they're trying to study

678
00:29:50,210 --> 00:29:47,640
that and there are microorganisms that

679
00:29:53,330 --> 00:29:50,220
hibernate and really horrific conditions

680
00:29:56,360 --> 00:29:53,340
you know and we're like really yeah

681
00:29:59,510 --> 00:29:56,370
really nasty chemicals and and they can

682
00:30:01,940 --> 00:29:59,520
be revived at different temperatures so

683
00:30:03,440 --> 00:30:01,950
so it's an active area of study yeah

684
00:30:06,649 --> 00:30:03,450
okay one more and then I'll let you guys

685
00:30:08,299 --> 00:30:06,659
go this one is from Hugo Burnham who's

686
00:30:11,360 --> 00:30:08,309
going and this one all addressed to you

687
00:30:12,950 --> 00:30:11,370
Ava you might know is there something

688
00:30:18,909 --> 00:30:12,960

similar to the hertzsprung-russell

689
00:30:26,690 --> 00:30:23,990
yes well I mean no yes and no I mean we

690
00:30:30,020 --> 00:30:26,700
have to like planets you've got rocky or

691
00:30:32,000 --> 00:30:30,030
super Earths and yeah the hospital a

692
00:30:34,190 --> 00:30:32,010
certain item is a question of evolution

693
00:30:36,770 --> 00:30:34,200
that I mean by the nuclear source of the

694
00:30:39,380 --> 00:30:36,780
start I mean if we can look at the

695
00:30:41,419 --> 00:30:39,390
diagram for planets in terms of

696
00:30:44,570 --> 00:30:41,429
luminosity ventures temperature that

697
00:30:46,970 --> 00:30:44,580
tell us how is going to cool off just

698
00:30:49,430 --> 00:30:46,980
provided that they have some energy

699
00:30:52,520 --> 00:30:49,440
source that that remains are the active

700
00:30:54,320 --> 00:30:52,530
energy releases from the contraction of

701
00:30:57,289 --> 00:30:54,330
the planet and things like that but

702
00:31:01,220 --> 00:30:57,299
those are much more simple drugs for a

703
00:31:02,390 --> 00:31:01,230
planet ok all right well um i guess i'm

704
00:31:05,419 --> 00:31:02,400
going to go ahead and stop there because

705
00:31:07,100 --> 00:31:05,429
you guys have to get going and i wanted

706
00:31:08,810 --> 00:31:07,110
there's just so much more i was hoping

707
00:31:10,370 --> 00:31:08,820
to be able to talk about this is a huge

708
00:31:12,340 --> 00:31:10,380
hugely interesting sub

709
00:31:15,530 --> 00:31:12,350
there's a whole there's a there is a

710
00:31:17,210 --> 00:31:15,540
symposium being held all week long here

711
00:31:18,860 --> 00:31:17,220
at the Institute many of the videos and

712
00:31:22,340 --> 00:31:18,870
talks are already posted i put the link

713
00:31:24,830 --> 00:31:22,350

to those webcast videos on our way on

714
00:31:27,530 --> 00:31:24,840
the event page here it's web cast out

715
00:31:29,510 --> 00:31:27,540
stsci edu and you go there and you can

716
00:31:31,070 --> 00:31:29,520
watch these talks you can that many of

717
00:31:33,740 --> 00:31:31,080
them are already archive some of them

718
00:31:35,930 --> 00:31:33,750
aren't but many of them are I don't know

719
00:31:37,310 --> 00:31:35,940
if avis is up yet or not she just gave

720
00:31:39,260 --> 00:31:37,320
it only about an hour ago a little over

721
00:31:41,810 --> 00:31:39,270
an hour ago so but I highly encourage

722
00:31:42,860 --> 00:31:41,820
you guys to check out these talks if

723
00:31:44,480 --> 00:31:42,870
you're interested in this question of

724
00:31:45,890 --> 00:31:44,490
habitability because they're being it's

725
00:31:48,050 --> 00:31:45,900
being looked at and discussed very

726
00:31:50,390 --> 00:31:48,060
seriously by astronomers right now at

727
00:31:51,950 --> 00:31:50,400
the Space Telescope Science Institute so

728
00:31:54,920 --> 00:31:51,960
I'm going to stop here guys I don't want

729
00:31:56,420 --> 00:31:54,930
to thank Mario Livio and Ava and Carol

730
00:31:59,690 --> 00:31:56,430
all of you guys thank you very much for

731
00:32:01,700 --> 00:31:59,700
joining me and talking about this i will

732
00:32:03,380 --> 00:32:01,710
look for more Hubble hangouts coming up

733
00:32:06,200 --> 00:32:03,390
in the future I think our next one Carol

734
00:32:07,910 --> 00:32:06,210
and I have scheduled will be with dr.

735
00:32:10,310 --> 00:32:07,920
Amy sumera we're going to be talking

736
00:32:13,670 --> 00:32:10,320
about looking at protoplanetary disks

737
00:32:16,040 --> 00:32:13,680
and exoplanets from Nick moss data and

738
00:32:18,260 --> 00:32:16,050

all kinds of other interesting topics so

739
00:32:20,450 --> 00:32:18,270
look for those in the coming weeks and