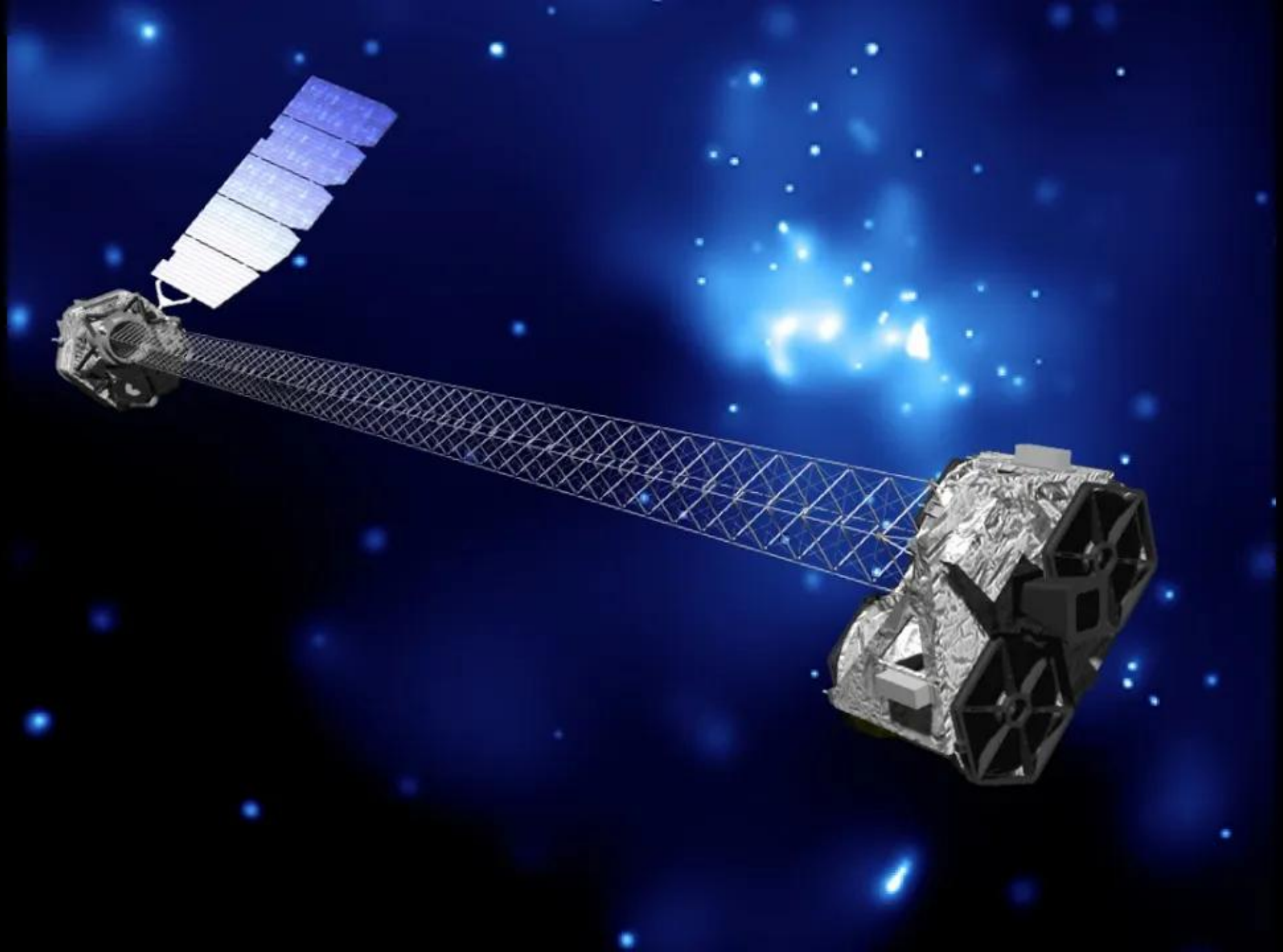

1
00:00:06,230 --> 00:00:04,630
nasa's jet propulsion laboratory

2
00:00:08,870 --> 00:00:06,240
presents

3
00:00:10,950 --> 00:00:08,880
the von carmen lecture a series of talks

4
00:00:14,230 --> 00:00:10,960
by scientists and engineers who are

5
00:00:15,970 --> 00:00:14,240
exploring our planet our solar system

6
00:00:23,349 --> 00:00:15,980
and all that lies beyond

7
00:00:25,589 --> 00:00:23,359
[Music]

8
00:00:28,390 --> 00:00:25,599
good evening ladies and gentlemen my

9
00:00:30,390 --> 00:00:28,400
name is mark razzie from gpl's office

10
00:00:32,229 --> 00:00:30,400
of communications and education

11
00:00:34,069 --> 00:00:32,239
and it is my pleasure to be your host

12
00:00:35,590 --> 00:00:34,079
and thank all of you for joining us

13
00:00:37,670 --> 00:00:35,600

so tonight we'll be talking about the

14
00:00:39,670 --> 00:00:37,680
new star x-ray telescope which is

15
00:00:40,709 --> 00:00:39,680
approaching the 10th anniversary of its

16
00:00:42,549 --> 00:00:40,719
launch

17
00:00:44,389 --> 00:00:42,559
now of course most of us know that

18
00:00:45,830 --> 00:00:44,399
x-rays are a commonly used medical

19
00:00:47,830 --> 00:00:45,840
diagnostic tool

20
00:00:50,389 --> 00:00:47,840
but they can also tell us a great deal

21
00:00:53,029 --> 00:00:50,399
about astronomical objects many such

22
00:00:54,790 --> 00:00:53,039
objects emit light in the x-ray band and

23
00:00:56,709 --> 00:00:54,800
by examining that light we can learn a

24
00:00:59,029 --> 00:00:56,719
lot about those objects

25
00:01:00,790 --> 00:00:59,039
but as we'll also learn tonight uh

26
00:01:02,790 --> 00:01:00,800
x-rays aren't the easiest things to

27
00:01:04,549 --> 00:01:02,800
observe but they can provide some

28
00:01:06,070 --> 00:01:04,559
amazing revelations

29
00:01:07,350 --> 00:01:06,080
so to handle the question and answer

30
00:01:09,270 --> 00:01:07,360
part of the program tonight is our

31
00:01:10,870 --> 00:01:09,280
co-host my friend and colleague and

32
00:01:13,270 --> 00:01:10,880
fellow office of communications and

33
00:01:14,950 --> 00:01:13,280
education member brian white good

34
00:01:17,030 --> 00:01:14,960
evening my friend

35
00:01:19,109 --> 00:01:17,040
good evening mark good evening folks

36
00:01:20,630 --> 00:01:19,119
first off stay tuned to a web page near

37
00:01:23,109 --> 00:01:20,640
you for more information on new star's

38
00:01:24,550 --> 00:01:23,119

10th anniversary on june 13th you can

39
00:01:27,830 --> 00:01:24,560
follow along with that mission to find

40
00:01:33,109 --> 00:01:27,840
out more information at nasa.gov

41
00:01:38,230 --> 00:01:36,390
as a reminder this is your space program

42
00:01:40,310 --> 00:01:38,240
and we want you to be involved we'll be

43
00:01:41,830 --> 00:01:40,320
taking your questions this evening you

44
00:01:43,590 --> 00:01:41,840
can ask those questions by using the

45
00:01:45,830 --> 00:01:43,600
chat feature in whatever platform you're

46
00:01:47,910 --> 00:01:45,840
on and if you don't see the chat hit

47
00:01:49,830 --> 00:01:47,920
refresh and that chat feature should be

48
00:01:51,749 --> 00:01:49,840
there lastly if we run into any

49
00:01:53,510 --> 00:01:51,759
technical difficulties please stay

50
00:01:56,069 --> 00:01:53,520
patient with us as we get those worked

51
00:01:58,149 --> 00:01:56,079
out now back to you mark

52
00:02:00,389 --> 00:01:58,159
thank you very much brian

53
00:02:02,389 --> 00:02:00,399
so our guest tonight from the california

54
00:02:04,789 --> 00:02:02,399
institute of technology

55
00:02:06,709 --> 00:02:04,799
is dr brian greffenstein who is a

56
00:02:08,949 --> 00:02:06,719
principal mission scientist on the new

57
00:02:11,029 --> 00:02:08,959
star telescope brian's interest in

58
00:02:12,390 --> 00:02:11,039
astronomy started pretty early and he

59
00:02:14,470 --> 00:02:12,400
fed that interest by working at the

60
00:02:15,670 --> 00:02:14,480
smithsonian air and space museum while

61
00:02:17,990 --> 00:02:15,680
in high school

62
00:02:20,470 --> 00:02:18,000
then he spent several summers interning

63
00:02:22,630 --> 00:02:20,480

at the u.s naval observatory he went on

64
00:02:24,790 --> 00:02:22,640
to earn a bs in physics from stanford

65
00:02:27,750 --> 00:02:24,800
and his phd in physics from uc santa

66
00:02:29,270 --> 00:02:27,760
cruz as a post-doc he moved to cal tech

67
00:02:30,390 --> 00:02:29,280
to work on the x-ray detectors for

68
00:02:32,070 --> 00:02:30,400
nustar

69
00:02:34,229 --> 00:02:32,080
and well he's kind of been there ever

70
00:02:36,710 --> 00:02:34,239
since now he's a scientist in the high

71
00:02:39,030 --> 00:02:36,720
energy astrophysics group good evening

72
00:02:40,630 --> 00:02:39,040
brian and thank you very much for

73
00:02:42,710 --> 00:02:40,640
joining us tonight

74
00:02:44,630 --> 00:02:42,720
hey mark thanks for having me

75
00:02:46,869 --> 00:02:44,640
so just to kick this thing off tell us a

76
00:02:49,190 --> 00:02:46,879
little bit about yourself

77
00:02:51,270 --> 00:02:49,200
sure so um i grew up outside of

78
00:02:52,949 --> 00:02:51,280
washington dc and you know everyone has

79
00:02:54,869 --> 00:02:52,959
that movie they watched over and over

80
00:02:56,949 --> 00:02:54,879
again as a kid and for me that was the

81
00:02:58,630 --> 00:02:56,959
right stuff which is the story of chuck

82
00:03:00,710 --> 00:02:58,640
yeager and the original mercury seven

83
00:03:02,790 --> 00:03:00,720
astronauts so i had space on the brain

84
00:03:03,990 --> 00:03:02,800
from a pretty early age and when i was

85
00:03:05,990 --> 00:03:04,000
growing up i had a great little

86
00:03:08,149 --> 00:03:06,000
telescope and even in the muggy suburbs

87
00:03:10,309 --> 00:03:08,159
around dc it was good enough to see the

88
00:03:12,550 --> 00:03:10,319

moons of jupiter and to see a pretty

89
00:03:15,830 --> 00:03:12,560
good image of mars when it was up

90
00:03:18,229 --> 00:03:15,840
once i got to college i got into working

91
00:03:19,830 --> 00:03:18,239
in physics labs i started to get into

92
00:03:21,110 --> 00:03:19,840
sort of the science of

93
00:03:23,030 --> 00:03:21,120
measuring things which is really what

94
00:03:24,710 --> 00:03:23,040
experimental physicists do is we build

95
00:03:26,390 --> 00:03:24,720
devices and we go out and measure things

96
00:03:27,990 --> 00:03:26,400
about the universe

97
00:03:30,550 --> 00:03:28,000
after i finished at stanford i went over

98
00:03:32,789 --> 00:03:30,560
to uc santa cruz uh where i got to work

99
00:03:34,789 --> 00:03:32,799
with my advisor david smith to design

100
00:03:36,949 --> 00:03:34,799
and build my first real instrument that

101
00:03:38,789 --> 00:03:36,959
i got to build from scratch so we built

102
00:03:40,550 --> 00:03:38,799
a gamma-ray detectors that went and flew

103
00:03:42,710 --> 00:03:40,560
around inside thunderstorms where jets

104
00:03:44,229 --> 00:03:42,720
of electrons the anti-electrons are

105
00:03:46,229 --> 00:03:44,239
running around nearly the speed of light

106
00:03:47,589 --> 00:03:46,239
and make lots and lots of gamma rays so

107
00:03:49,350 --> 00:03:47,599
to borrow a turn from david that's sort

108
00:03:52,149 --> 00:03:49,360
of when i started to think myself as an

109
00:03:53,509 --> 00:03:52,159
experimental astrophysicist so once i

110
00:03:55,030 --> 00:03:53,519
graduated i was fortunate enough to move

111
00:03:57,830 --> 00:03:55,040
down the i-5

112
00:03:59,190 --> 00:03:57,840
here to la and work at caltech to build

113
00:04:00,550 --> 00:03:59,200

the x-ray cameras for this brand new

114
00:04:03,110 --> 00:04:00,560
x-ray satellite that was going to launch

115
00:04:04,949 --> 00:04:03,120
in just a few years called nustar now

116
00:04:07,190 --> 00:04:04,959
nustar you know in nasa everything's an

117
00:04:08,869 --> 00:04:07,200
acronym and nustar is no different it

118
00:04:11,190 --> 00:04:08,879
stands for the nuclear spectroscopic

119
00:04:12,710 --> 00:04:11,200
telescope array uh array because there's

120
00:04:14,550 --> 00:04:12,720
actually two telescopes on new star they

121
00:04:15,750 --> 00:04:14,560
are completely identical so i'm really

122
00:04:17,270 --> 00:04:15,760
excited to talk with you about that

123
00:04:18,229 --> 00:04:17,280
tonight

124
00:04:19,830 --> 00:04:18,239
so

125
00:04:22,550 --> 00:04:19,840
what what is it what's the day-to-day

126
00:04:24,710 --> 00:04:22,560
look like for a scientist like yourself

127
00:04:27,110 --> 00:04:24,720
sure so i call myself sort of a bolts to

128
00:04:29,189 --> 00:04:27,120
bits physics scientist so i like working

129
00:04:30,790 --> 00:04:29,199
with my hands in the lab and i also

130
00:04:32,950 --> 00:04:30,800
write a lot of computer software that

131
00:04:35,350 --> 00:04:32,960
astronomers use to take the data from

132
00:04:37,030 --> 00:04:35,360
the satellite and use it to make uh all

133
00:04:38,710 --> 00:04:37,040
of the images inspector that we use to

134
00:04:40,950 --> 00:04:38,720
do really amazing science

135
00:04:42,710 --> 00:04:40,960
so once you start launched in 2012 i got

136
00:04:44,790 --> 00:04:42,720
the chance to get involved back in

137
00:04:46,550 --> 00:04:44,800
astronomy uh and get involved a lot of

138
00:04:47,749 --> 00:04:46,560

the science that new stars doing you

139
00:04:49,510 --> 00:04:47,759
know whenever you look at sort of the

140
00:04:51,030 --> 00:04:49,520
brightest things with your telescope but

141
00:04:53,590 --> 00:04:51,040
the faintest things with your telescope

142
00:04:54,870 --> 00:04:53,600
really you really want someone who knows

143
00:04:56,629 --> 00:04:54,880
all of the quirks about how the

144
00:04:59,110 --> 00:04:56,639
instrument works to get the most science

145
00:05:00,469 --> 00:04:59,120
out most bang for your buck and for me

146
00:05:01,590 --> 00:05:00,479
for new starter that's someone like me

147
00:05:03,590 --> 00:05:01,600
and a couple of the other principal

148
00:05:05,909 --> 00:05:03,600
mission scientists who got involved in

149
00:05:07,189 --> 00:05:05,919
all kinds of interesting science um so i

150
00:05:09,430 --> 00:05:07,199
get to work on some of the brightest

151
00:05:10,870 --> 00:05:09,440
things we do like solar flares to things

152
00:05:12,710 --> 00:05:10,880
billions sometimes fainter like the

153
00:05:14,950 --> 00:05:12,720
radioactive ash left behind by supernova

154
00:05:17,110 --> 00:05:14,960
explosions so all of this lives under

155
00:05:18,629 --> 00:05:17,120
the category of high energy astrophysics

156
00:05:21,909 --> 00:05:18,639
which is which is where we're mostly

157
00:05:22,790 --> 00:05:21,919
dealing with x-rays and gamma rays

158
00:05:24,310 --> 00:05:22,800
so

159
00:05:26,150 --> 00:05:24,320
tell us a little more than like where

160
00:05:28,310 --> 00:05:26,160
x-ray what x-rays really are like where

161
00:05:30,070 --> 00:05:28,320
they fall on the spectrum

162
00:05:32,469 --> 00:05:30,080
sure so let's let's bring up uh slide

163
00:05:33,749 --> 00:05:32,479

number one

164
00:05:35,270 --> 00:05:33,759
all right great so what we're looking at

165
00:05:37,350 --> 00:05:35,280
here is a nice little cartoon showing

166
00:05:39,590 --> 00:05:37,360
the electromagnetic spectrum so in

167
00:05:41,510 --> 00:05:39,600
everyday life we think about light uh

168
00:05:43,510 --> 00:05:41,520
which is when we talk about it you know

169
00:05:45,510 --> 00:05:43,520
with my son you know it's light that

170
00:05:47,189 --> 00:05:45,520
comes from the sun or from a light bulb

171
00:05:49,270 --> 00:05:47,199
in the room and then we use words like

172
00:05:51,590 --> 00:05:49,280
radio waves that carry the music that we

173
00:05:53,830 --> 00:05:51,600
listen to in our car and our cell phone

174
00:05:55,670 --> 00:05:53,840
signals and then you know we go to

175
00:05:57,510 --> 00:05:55,680
x-rays which is what we might encounter

176
00:05:59,430 --> 00:05:57,520
when we go to the dentist's office now

177
00:06:00,710 --> 00:05:59,440
all of these waves are actually all

178
00:06:01,590 --> 00:06:00,720
light they're just different kinds of

179
00:06:02,790 --> 00:06:01,600
light

180
00:06:04,390 --> 00:06:02,800
so astronomers are kind of like

181
00:06:06,469 --> 00:06:04,400
detectives where the only information we

182
00:06:08,150 --> 00:06:06,479
get about the universe tends to be light

183
00:06:10,309 --> 00:06:08,160
that comes from a source

184
00:06:11,350 --> 00:06:10,319
so what we figured out over the years

185
00:06:13,749 --> 00:06:11,360
and you can sort of see this on the

186
00:06:15,430 --> 00:06:13,759
bottom here is that as things get hotter

187
00:06:16,950 --> 00:06:15,440
the light that they emit tends to get

188
00:06:18,469 --> 00:06:16,960

more towards the blue

189
00:06:20,230 --> 00:06:18,479
if you take our star which is a few

190
00:06:22,150 --> 00:06:20,240
thousand degrees it'll emit most of its

191
00:06:24,230 --> 00:06:22,160
light in the infrared in the optical

192
00:06:26,790 --> 00:06:24,240
uh if you take a much hotter star it'll

193
00:06:28,230 --> 00:06:26,800
look bluer and if you get a really uh a

194
00:06:29,749 --> 00:06:28,240
bunch of really hot material it'll

195
00:06:31,990 --> 00:06:29,759
actually glow in the ultraviolet and the

196
00:06:33,510 --> 00:06:32,000
x-rays so astronomers use different

197
00:06:34,710 --> 00:06:33,520
kinds of telescopes to look at different

198
00:06:36,230 --> 00:06:34,720
kinds of light to figure out how the

199
00:06:37,350 --> 00:06:36,240
universe works

200
00:06:39,270 --> 00:06:37,360
now the last thing i want to point out

201
00:06:40,790 --> 00:06:39,280
on this slide is that the top bar there

202
00:06:43,110 --> 00:06:40,800
which shows you what kind of light makes

203
00:06:45,350 --> 00:06:43,120
it through down to the ground um you

204
00:06:46,469 --> 00:06:45,360
know obviously we we see optical light

205
00:06:47,510 --> 00:06:46,479
that's the light that we see with our

206
00:06:49,110 --> 00:06:47,520
eyes

207
00:06:50,550 --> 00:06:49,120
but most of the other light gets blocked

208
00:06:52,309 --> 00:06:50,560
by our atmosphere and especially the

209
00:06:54,309 --> 00:06:52,319
high energy light the x-rays and gamma

210
00:06:55,510 --> 00:06:54,319
rays our atmosphere actually protects us

211
00:06:57,350 --> 00:06:55,520
from all of that harmful radiation

212
00:06:59,670 --> 00:06:57,360
that's coming in from other stars and

213
00:07:01,270 --> 00:06:59,680

other places in the universe now this

214
00:07:02,629 --> 00:07:01,280
means that if you want to study some of

215
00:07:03,990 --> 00:07:02,639
the hottest and densest material in the

216
00:07:06,710 --> 00:07:04,000
universe you actually have to go to

217
00:07:07,909 --> 00:07:06,720
space which is where new star comes in

218
00:07:10,070 --> 00:07:07,919
so let's go to

219
00:07:11,909 --> 00:07:10,080
slide number two

220
00:07:13,749 --> 00:07:11,919
great so um i've been working on new

221
00:07:15,510 --> 00:07:13,759
star for most of my scientific career

222
00:07:17,670 --> 00:07:15,520
that's me in in the lab on the bottom

223
00:07:19,189 --> 00:07:17,680
left there we're working on

224
00:07:20,790 --> 00:07:19,199
calibrating the flight detectors before

225
00:07:22,790 --> 00:07:20,800
they were bolted on to nustar and you

226
00:07:24,790 --> 00:07:22,800
can see the the other scientists that

227
00:07:26,469 --> 00:07:24,800
worked on the detectors above me or some

228
00:07:27,909 --> 00:07:26,479
of us and then the whole instrument

229
00:07:29,909 --> 00:07:27,919
being put together out in dulles

230
00:07:32,070 --> 00:07:29,919
virginia now before i go on i just want

231
00:07:33,430 --> 00:07:32,080
to emphasize that there's a huge team of

232
00:07:35,350 --> 00:07:33,440
engineers instrument scientists

233
00:07:37,029 --> 00:07:35,360
technicians electrical engineers mission

234
00:07:38,469 --> 00:07:37,039
operations experts

235
00:07:40,309 --> 00:07:38,479
all of those people work together on a

236
00:07:41,510 --> 00:07:40,319
mission like new start to make it happen

237
00:07:43,270 --> 00:07:41,520
um and new star wars is actually an

238
00:07:45,430 --> 00:07:43,280

international collaboration it's led

239
00:07:47,350 --> 00:07:45,440
here by the pi fiona harrison who's my

240
00:07:48,790 --> 00:07:47,360
boss here at caltech

241
00:07:50,629 --> 00:07:48,800
who's been our fearless leader for for

242
00:07:52,950 --> 00:07:50,639
many many years now and the cameras were

243
00:07:54,869 --> 00:07:52,960
actually built about two two stores down

244
00:07:56,230 --> 00:07:54,879
from where i'm sitting right now uh we

245
00:07:58,309 --> 00:07:56,240
partnered with our mission operations

246
00:07:59,830 --> 00:07:58,319
team at uc berkeley they're fantastic

247
00:08:03,029 --> 00:07:59,840
and then colombia and nasa goddard help

248
00:08:05,189 --> 00:08:03,039
build the telescopes uh on nustar

249
00:08:07,350 --> 00:08:05,199
we have international partners at dtu

250
00:08:09,029 --> 00:08:07,360
and denmark and the aussie space uh the

251
00:08:10,309 --> 00:08:09,039
italian space agency provides the ground

252
00:08:11,350 --> 00:08:10,319
station that we actually use to talk to

253
00:08:13,830 --> 00:08:11,360
new star

254
00:08:15,189 --> 00:08:13,840
um nustar is flying in space so we had a

255
00:08:16,950 --> 00:08:15,199
spacecraft partner which is orbital

256
00:08:18,869 --> 00:08:16,960
sciences which is now part of northrop

257
00:08:20,550 --> 00:08:18,879
grumman and actually they're they're

258
00:08:22,309 --> 00:08:20,560
headquartered in dulles which is about

259
00:08:23,670 --> 00:08:22,319
30 minutes from where i grew up

260
00:08:24,950 --> 00:08:23,680
so it's one of the things got me really

261
00:08:26,710 --> 00:08:24,960
excited about coming down to caltech

262
00:08:28,629 --> 00:08:26,720
because i got to work on this this new

263
00:08:30,550 --> 00:08:28,639

space telescope i got to actually get in

264
00:08:32,310 --> 00:08:30,560
the lab and get my hands on hardware

265
00:08:34,070 --> 00:08:32,320
that was going to space

266
00:08:35,430 --> 00:08:34,080
um so it was really exciting to be part

267
00:08:39,190 --> 00:08:35,440
of the team working on this instrument

268
00:08:41,430 --> 00:08:39,200
and uh it was it was a really great time

269
00:08:43,350 --> 00:08:41,440
so what makes uh an x-ray telescope like

270
00:08:44,949 --> 00:08:43,360
different from a telescope

271
00:08:46,710 --> 00:08:44,959
you know an amateur astronomer say might

272
00:08:48,870 --> 00:08:46,720
have in their backyard

273
00:08:50,310 --> 00:08:48,880
right so first off it's in space uh and

274
00:08:52,630 --> 00:08:50,320
but even if you took the the little

275
00:08:54,470 --> 00:08:52,640
telescope i had growing up and put it in

276
00:08:56,550 --> 00:08:54,480
space you know you won't instantly have

277
00:08:59,269 --> 00:08:56,560
an x-ray telescope uh let's go ahead and

278
00:09:01,430 --> 00:08:59,279
play uh movie number three

279
00:09:03,269 --> 00:09:01,440
so x-rays get absorbed by mirrors they

280
00:09:05,190 --> 00:09:03,279
don't like to reflect off in a normal

281
00:09:06,310 --> 00:09:05,200
incidence angle so you can't make a

282
00:09:08,070 --> 00:09:06,320
mirror like that instead you have to

283
00:09:10,470 --> 00:09:08,080
make a mirror like this so these are

284
00:09:12,630 --> 00:09:10,480
conical shells that deflect the x-rays

285
00:09:14,790 --> 00:09:12,640
just a little bit so each shell here

286
00:09:17,030 --> 00:09:14,800
deflects the x-ray by about a degree and

287
00:09:18,550 --> 00:09:17,040
it focuses down onto your camera which

288
00:09:20,470 --> 00:09:18,560

has to be really far away from your

289
00:09:23,110 --> 00:09:20,480
finger optics so the typical focal

290
00:09:24,230 --> 00:09:23,120
lengths here are about 6 or 10 meters or

291
00:09:26,230 --> 00:09:24,240
30 feet

292
00:09:27,990 --> 00:09:26,240
in the case of nustar

293
00:09:32,949 --> 00:09:28,000
so

294
00:09:33,910 --> 00:09:32,959
unique part about an x-ray telescope and

295
00:09:35,190 --> 00:09:33,920
how it's different from what you

296
00:09:36,630 --> 00:09:35,200
actually might have

297
00:09:39,350 --> 00:09:36,640
sort of with your standard experience

298
00:09:40,949 --> 00:09:39,360
with amateur telescopes

299
00:09:42,630 --> 00:09:40,959
so then like what what is nustar

300
00:09:44,870 --> 00:09:42,640
specifically

301
00:09:47,190 --> 00:09:44,880
so nustar is a is a smex it's something

302
00:09:48,630 --> 00:09:47,200
called a small explorer this used to be

303
00:09:50,470 --> 00:09:48,640
the smallest thing that nasa launched

304
00:09:51,750 --> 00:09:50,480
into space now nasa launches these

305
00:09:52,790 --> 00:09:51,760
little cubesats which are the size of

306
00:09:54,949 --> 00:09:52,800
shoebox

307
00:09:57,190 --> 00:09:54,959
um nustar the whole observatory weighed

308
00:09:58,070 --> 00:09:57,200
about 150 kilograms so less than 800

309
00:09:59,350 --> 00:09:58,080
pounds

310
00:10:01,269 --> 00:09:59,360
and to get to space you had to fit

311
00:10:03,110 --> 00:10:01,279
inside a small launch vehicle falcon 9's

312
00:10:04,230 --> 00:10:03,120
weren't really a thing back then

313
00:10:05,509 --> 00:10:04,240

and what i'm going to tell you about

314
00:10:07,269 --> 00:10:05,519
tonight is that even though we were a

315
00:10:08,870 --> 00:10:07,279
small explorer we've gotten about 10

316
00:10:10,710 --> 00:10:08,880
years of really big science out of this

317
00:10:12,949 --> 00:10:10,720
telescope so let's go on to the next

318
00:10:14,470 --> 00:10:12,959
image

319
00:10:16,550 --> 00:10:14,480
so this is what nustar looked like on

320
00:10:18,470 --> 00:10:16,560
the ground so on the left side you can

321
00:10:20,310 --> 00:10:18,480
see the whole instrument this is the

322
00:10:22,069 --> 00:10:20,320
telescope and the detectors sitting on

323
00:10:23,590 --> 00:10:22,079
top of the spacecraft the whole

324
00:10:25,430 --> 00:10:23,600
instrument was almost exactly as tall as

325
00:10:26,870 --> 00:10:25,440
i am i'm about six foot three so this is

326
00:10:28,790 --> 00:10:26,880
it's about two meters tall from the

327
00:10:30,310 --> 00:10:28,800
bottom to the top you can see the solar

328
00:10:31,990 --> 00:10:30,320
panels wrapped around the sides of the

329
00:10:33,750 --> 00:10:32,000
observatory and the reason the

330
00:10:35,190 --> 00:10:33,760
instrument was so small that it had to

331
00:10:37,110 --> 00:10:35,200
get to space you had to fit inside of a

332
00:10:39,590 --> 00:10:37,120
pretty small rocket so on the right side

333
00:10:41,829 --> 00:10:39,600
there you can actually see new stars

334
00:10:43,670 --> 00:10:41,839
inside the nose cone of a pegasus rocket

335
00:10:45,590 --> 00:10:43,680
up at the vandenberg air force base just

336
00:10:47,430 --> 00:10:45,600
near santa barbara here

337
00:10:48,790 --> 00:10:47,440
now the pegasus is a fun launch because

338
00:10:51,269 --> 00:10:48,800

this actually launches from the bottom

339
00:10:53,190 --> 00:10:51,279
of a plane uh you can see it strapped to

340
00:10:55,430 --> 00:10:53,200
the bottom of a stargazer l-1011

341
00:10:57,829 --> 00:10:55,440
aircraft there on the bottom right uh

342
00:10:59,670 --> 00:10:57,839
the entire instrument payload is just in

343
00:11:01,590 --> 00:10:59,680
the the nose cone just the far left side

344
00:11:02,870 --> 00:11:01,600
of the rocket now being on a plane gives

345
00:11:04,069 --> 00:11:02,880
you a lot of flexibility in where you

346
00:11:05,829 --> 00:11:04,079
want to launch from you can watch from

347
00:11:07,509 --> 00:11:05,839
vandenberg you can get your plane out to

348
00:11:09,590 --> 00:11:07,519
sort of almost wherever you want to go

349
00:11:10,870 --> 00:11:09,600
but the volume and mass or the weight of

350
00:11:12,870 --> 00:11:10,880
the telescope that you can launch is

351
00:11:15,190 --> 00:11:12,880
extremely limited so let's go and play

352
00:11:16,949 --> 00:11:15,200
the next movie

353
00:11:18,870 --> 00:11:16,959
so this is what a pegasus launch looks

354
00:11:21,110 --> 00:11:18,880
like uh this is not nustar new star

355
00:11:22,550 --> 00:11:21,120
launched from uh kwajalein atoll in the

356
00:11:24,870 --> 00:11:22,560
south pacific about four o'clock the

357
00:11:26,069 --> 00:11:24,880
morning we didn't have a chase plane

358
00:11:27,190 --> 00:11:26,079
but you can sort of see the instrument

359
00:11:28,470 --> 00:11:27,200
taking off

360
00:11:29,750 --> 00:11:28,480
uh your

361
00:11:31,190 --> 00:11:29,760
hold your breath while every time the

362
00:11:32,710 --> 00:11:31,200
plane goes up and down

363
00:11:35,110 --> 00:11:32,720

the rock the rocket gets dropped from

364
00:11:37,509 --> 00:11:35,120
the aircraft you count for seven seconds

365
00:11:40,310 --> 00:11:37,519
hope that you hear the rocket uh turn on

366
00:11:41,910 --> 00:11:40,320
there it goes the pegasus shoots forward

367
00:11:42,870 --> 00:11:41,920
and then injects your satellite into

368
00:11:44,870 --> 00:11:42,880
orbit

369
00:11:46,470 --> 00:11:44,880
now you know i liked

370
00:11:48,470 --> 00:11:46,480
chucky here in the x1 but this there's

371
00:11:49,829 --> 00:11:48,480
no chuck yeager in there right to make

372
00:11:51,829 --> 00:11:49,839
sure that the thing uh thing actually

373
00:11:53,750 --> 00:11:51,839
went off so it was pretty white knuckle

374
00:11:55,829 --> 00:11:53,760
stuff while the uh while the uh the

375
00:11:57,030 --> 00:11:55,839
rocket dropped away all we saw was just

376
00:11:58,870 --> 00:11:57,040
falling out at the bottom of the

377
00:12:00,150 --> 00:11:58,880
aircraft until we heard the confirmation

378
00:12:01,990 --> 00:12:00,160
from the controller that the rocket

379
00:12:04,389 --> 00:12:02,000
stage had ignited

380
00:12:06,150 --> 00:12:04,399
so that's how these target got to space

381
00:12:07,670 --> 00:12:06,160
so you said you had a really long focal

382
00:12:09,190 --> 00:12:07,680
length

383
00:12:11,190 --> 00:12:09,200
i'm required for this type of telescope

384
00:12:13,829 --> 00:12:11,200
like how did you how did you manage to

385
00:12:16,310 --> 00:12:13,839
get that in the nose cone of this rocket

386
00:12:17,910 --> 00:12:16,320
sure so uh so nustar is actually a

387
00:12:20,710 --> 00:12:17,920
transformer so let's go and play the

388
00:12:22,870 --> 00:12:20,720

next animation number six

389
00:12:24,310 --> 00:12:22,880
all right so this is showing what nustar

390
00:12:26,069 --> 00:12:24,320
looked like after we got into space and

391
00:12:27,190 --> 00:12:26,079
we deployed the solar panels we had

392
00:12:29,190 --> 00:12:27,200
figured out how to point this the

393
00:12:31,590 --> 00:12:29,200
spacecraft there's actually a little

394
00:12:33,590 --> 00:12:31,600
thing called a deployable mast that sits

395
00:12:35,590 --> 00:12:33,600
down between the telescopes which you

396
00:12:37,430 --> 00:12:35,600
can see the two telescopes there and the

397
00:12:39,030 --> 00:12:37,440
detectors which are down at the bottom

398
00:12:41,190 --> 00:12:39,040
there's a single motor sitting inside

399
00:12:44,389 --> 00:12:41,200
that canister there that's pushing out

400
00:12:46,550 --> 00:12:44,399
this little tinkertoy uh mass that's

401
00:12:48,470 --> 00:12:46,560
deploying these things called bays so

402
00:12:51,110 --> 00:12:48,480
the bays once they go out they lock into

403
00:12:52,870 --> 00:12:51,120
place and that pushes the optics and the

404
00:12:54,310 --> 00:12:52,880
detectors apart until you get to the

405
00:12:55,590 --> 00:12:54,320
focal length we need for new star which

406
00:12:58,069 --> 00:12:55,600
is 10 meters

407
00:13:00,069 --> 00:12:58,079
so 10 meters is 30 feet uh which is

408
00:13:01,670 --> 00:13:00,079
about the length of a school bus so this

409
00:13:03,030 --> 00:13:01,680
is not a small observatory once you

410
00:13:04,150 --> 00:13:03,040
actually get it out and deployed into

411
00:13:06,230 --> 00:13:04,160
space

412
00:13:08,949 --> 00:13:06,240
now uh on the ground this is obviously

413
00:13:10,710 --> 00:13:08,959

an animation um we don't have uh any

414
00:13:12,470 --> 00:13:10,720
video of this happening and on the

415
00:13:13,829 --> 00:13:12,480
ground all we saw was the one little

416
00:13:15,110 --> 00:13:13,839
motor that's driving it every time one

417
00:13:17,269 --> 00:13:15,120
of those bays locked into place you'd

418
00:13:18,550 --> 00:13:17,279
see a little blip happen so we're

419
00:13:20,470 --> 00:13:18,560
sitting in the control room at uc

420
00:13:22,150 --> 00:13:20,480
berkeley hoping that we count the right

421
00:13:23,750 --> 00:13:22,160
number of blips and have the whole

422
00:13:26,310 --> 00:13:23,760
observatory deploy so this is sort of

423
00:13:29,190 --> 00:13:26,320
our second really exciting moment on the

424
00:13:30,550 --> 00:13:29,200
uh on deploying the observatory so i

425
00:13:32,230 --> 00:13:30,560
think it took about 20 minutes that

426
00:13:33,910 --> 00:13:32,240
animation was sped up i felt like it

427
00:13:35,430 --> 00:13:33,920
took about two hours

428
00:13:36,949 --> 00:13:35,440
everything went well the mass fully

429
00:13:39,269 --> 00:13:36,959
deployed and after that we had a fully

430
00:13:40,710 --> 00:13:39,279
functioning x-ray telescope so first

431
00:13:42,470 --> 00:13:40,720
light was looking at the bright x-ray

432
00:13:44,470 --> 00:13:42,480
source cygnus x1 which is actually what

433
00:13:47,509 --> 00:13:44,480
we're looking at right now again

434
00:13:49,189 --> 00:13:47,519
on june 28 2012.

435
00:13:51,590 --> 00:13:49,199
that's that's cool

436
00:13:54,069 --> 00:13:51,600
um so i know we've studied x-rays

437
00:13:55,750 --> 00:13:54,079
in space with other telescopes

438
00:13:57,350 --> 00:13:55,760

how is nustar different from those other

439
00:13:59,590 --> 00:13:57,360
x-ray telescopes

440
00:14:02,230 --> 00:13:59,600
yeah so nustar is the first telescope

441
00:14:03,430 --> 00:14:02,240
that focuses high-energy x-rays and

442
00:14:05,110 --> 00:14:03,440
we're actually very lucky right now

443
00:14:06,470 --> 00:14:05,120
because there are a lot of telescopes up

444
00:14:09,829 --> 00:14:06,480
in space that are studying the x-ray

445
00:14:11,750 --> 00:14:09,839
band so let's go to the next slide

446
00:14:13,750 --> 00:14:11,760
so this is showing two of the big other

447
00:14:15,430 --> 00:14:13,760
observatories this is chandra which is

448
00:14:17,829 --> 00:14:15,440
one of the nasa great observatories that

449
00:14:20,310 --> 00:14:17,839
launched in the 90s and esa's x-men

450
00:14:22,550 --> 00:14:20,320
newton observatory so these are the two

451
00:14:23,430 --> 00:14:22,560
really workhorse x-ray observatories

452
00:14:25,590 --> 00:14:23,440
that have been up and they've been

453
00:14:27,350 --> 00:14:25,600
studying mostly the low energy x-ray sky

454
00:14:29,110 --> 00:14:27,360
you can sort of see

455
00:14:31,750 --> 00:14:29,120
the gradient there of the band of light

456
00:14:33,990 --> 00:14:31,760
that it that chandra and xmm see

457
00:14:35,670 --> 00:14:34,000
now when you want to go to high energies

458
00:14:38,150 --> 00:14:35,680
you need completely different kinds of

459
00:14:40,389 --> 00:14:38,160
cameras for that to work so nustar is

460
00:14:42,629 --> 00:14:40,399
the first telescope in space to actually

461
00:14:45,030 --> 00:14:42,639
focus high energy x-rays which gives you

462
00:14:46,470 --> 00:14:45,040
an entirely new view of the universe

463
00:14:47,829 --> 00:14:46,480

now there's a bunch of important reasons

464
00:14:50,310 --> 00:14:47,839
for why you'd want to look at high

465
00:14:53,030 --> 00:14:50,320
energy x-rays one is that space isn't

466
00:14:55,590 --> 00:14:53,040
empty there's a lot of gas and dust in

467
00:14:56,550 --> 00:14:55,600
galaxies and that actually blocks a lot

468
00:14:59,189 --> 00:14:56,560
of the

469
00:15:01,509 --> 00:14:59,199
soft x-rays that chandra and xmm see so

470
00:15:02,949 --> 00:15:01,519
if you want to look down deep into the

471
00:15:05,269 --> 00:15:02,959
center of black holes you actually want

472
00:15:07,110 --> 00:15:05,279
to use high-energy x-rays now the high

473
00:15:08,550 --> 00:15:07,120
energy x-rays and the low energy x-rays

474
00:15:09,990 --> 00:15:08,560
work together to really give you a

475
00:15:12,069 --> 00:15:10,000
complete picture about what's going on a

476
00:15:13,829 --> 00:15:12,079
lot of these systems but there are cases

477
00:15:15,350 --> 00:15:13,839
which we'll talk about in a minute

478
00:15:16,790 --> 00:15:15,360
where you can only do some of the

479
00:15:19,110 --> 00:15:16,800
science with the high energy x-rays and

480
00:15:22,069 --> 00:15:19,120
that's where new star comes in

481
00:15:23,750 --> 00:15:22,079
very very cool um we're about 15 minutes

482
00:15:25,350 --> 00:15:23,760
in so this might be a good point to take

483
00:15:27,030 --> 00:15:25,360
some questions

484
00:15:29,189 --> 00:15:27,040
mr white how's it going out there in the

485
00:15:30,870 --> 00:15:29,199
chat oh the chat's going great lots of

486
00:15:32,629 --> 00:15:30,880
great questions out here today and we

487
00:15:34,550 --> 00:15:32,639
actually just got one from humza on

488
00:15:37,189 --> 00:15:34,560

facebook kind of has to deal with what

489
00:15:40,550 --> 00:15:37,199
you just said brian um how does nasa

490
00:15:43,509 --> 00:15:40,560
convert these x-ray images into visible

491
00:15:45,910 --> 00:15:43,519
ones with things that we can see

492
00:15:48,790 --> 00:15:45,920
so what we do is we generally make false

493
00:15:50,069 --> 00:15:48,800
color images so we take the x-ray colors

494
00:15:51,829 --> 00:15:50,079
uh these are obviously not things that

495
00:15:53,829 --> 00:15:51,839
our eyes are designed to see that's what

496
00:15:55,829 --> 00:15:53,839
we make the cameras for and we turn

497
00:15:57,910 --> 00:15:55,839
those colors into

498
00:16:00,790 --> 00:15:57,920
images that we can see and interpret

499
00:16:03,590 --> 00:16:00,800
ourselves so a lot of times there are

500
00:16:06,150 --> 00:16:03,600
specific colors that come from different

501
00:16:07,430 --> 00:16:06,160
atoms and sort of like a neon bulb is

502
00:16:08,949 --> 00:16:07,440
always pink

503
00:16:10,629 --> 00:16:08,959
and you can take that x-ray color and

504
00:16:12,870 --> 00:16:10,639
turn it into something like red for

505
00:16:14,069 --> 00:16:12,880
example

506
00:16:17,670 --> 00:16:14,079
very cool

507
00:16:18,870 --> 00:16:17,680
um another question that we got from our

508
00:16:22,790 --> 00:16:18,880
from

509
00:16:26,870 --> 00:16:22,800
best boy log on youtube they ask what

510
00:16:28,150 --> 00:16:26,880
can nustar tell us about magnetars

511
00:16:31,030 --> 00:16:28,160
ah that is

512
00:16:33,509 --> 00:16:31,040
so first off yay youtube uh

513
00:16:35,269 --> 00:16:33,519

second nustar actually tells us a lot

514
00:16:37,670 --> 00:16:35,279
about magnetars some of the youngest

515
00:16:40,470 --> 00:16:37,680
magnetars that have ever been observed

516
00:16:42,790 --> 00:16:40,480
were ones that were detected with nustar

517
00:16:44,710 --> 00:16:42,800
um we cover a unique part of the

518
00:16:46,069 --> 00:16:44,720
bandpass for magnetars it really tells a

519
00:16:47,269 --> 00:16:46,079
lot about the magnetic fields and what's

520
00:16:50,629 --> 00:16:47,279
going on in

521
00:16:53,910 --> 00:16:52,069
great and we'll keep more questions

522
00:16:55,430 --> 00:16:53,920
coming but back to you mark

523
00:16:58,790 --> 00:16:55,440
all right thanks ryan

524
00:17:01,350 --> 00:16:58,800
so uh brian what gets us here tonight

525
00:17:03,749 --> 00:17:01,360
right so we're here because on june 13th

526
00:17:05,189 --> 00:17:03,759
2012 around 9 a.m pacific time new star

527
00:17:07,110 --> 00:17:05,199
launched into space

528
00:17:09,270 --> 00:17:07,120
so we're in low earth orbit which means

529
00:17:10,949 --> 00:17:09,280
we're only about 600 kilometers up and

530
00:17:12,870 --> 00:17:10,959
we actually orbit the earth pretty

531
00:17:15,669 --> 00:17:12,880
rapidly we make it from the santa monica

532
00:17:17,510 --> 00:17:15,679
pier to jpl in about 10 seconds so that

533
00:17:19,429 --> 00:17:17,520
beats traffic

534
00:17:22,230 --> 00:17:19,439
now we that means we orbit the earth

535
00:17:25,669 --> 00:17:22,240
once every 96 minutes so since launch

536
00:17:27,510 --> 00:17:25,679
we've actually done over 54 000 orbits

537
00:17:29,190 --> 00:17:27,520
and performed over 3 500 science

538
00:17:31,510 --> 00:17:29,200

observations of all kinds of science

539
00:17:33,590 --> 00:17:31,520
targets from observations of giant black

540
00:17:35,110 --> 00:17:33,600
holes in the distant universe to things

541
00:17:36,950 --> 00:17:35,120
in our own solar system like flares from

542
00:17:39,350 --> 00:17:36,960
our sun and high energy aurora around

543
00:17:41,110 --> 00:17:39,360
jupiter now there have been over 1100

544
00:17:42,950 --> 00:17:41,120
science papers based on nustar from

545
00:17:44,870 --> 00:17:42,960
scientists all over the world so it'd be

546
00:17:47,110 --> 00:17:44,880
impossible for me to give any kind of

547
00:17:48,310 --> 00:17:47,120
real sampling of what nustar can do so

548
00:17:50,470 --> 00:17:48,320
instead i'm gonna i'd like to tell you

549
00:17:51,669 --> 00:17:50,480
about two stories about nustar's major

550
00:17:52,950 --> 00:17:51,679
discoveries and give you some kind of

551
00:17:54,789 --> 00:17:52,960
flavor of the kind of science that

552
00:17:56,710 --> 00:17:54,799
nustar does

553
00:17:57,750 --> 00:17:56,720
all right very cool uh so what's the

554
00:17:58,950 --> 00:17:57,760
first one

555
00:18:01,350 --> 00:17:58,960
all right so let's go to image number

556
00:18:03,510 --> 00:18:01,360
eight

557
00:18:05,510 --> 00:18:03,520
okay so most of us don't really think

558
00:18:07,669 --> 00:18:05,520
about the heat that comes from our star

559
00:18:09,430 --> 00:18:07,679
uh the sun but what's really going on

560
00:18:10,390 --> 00:18:09,440
inside the star is that it's a nuclear

561
00:18:11,909 --> 00:18:10,400
furnace

562
00:18:14,390 --> 00:18:11,919
the core of the star is busily

563
00:18:15,590 --> 00:18:14,400

converting fusing hydrogen to helium so

564
00:18:17,190 --> 00:18:15,600
it's basically taking the gravitational

565
00:18:19,110 --> 00:18:17,200
energy the squeezing the hydrogen

566
00:18:20,789 --> 00:18:19,120
together and it's fusing the hydrogen

567
00:18:22,230 --> 00:18:20,799
into helium which releases a bit of

568
00:18:24,630 --> 00:18:22,240
energy or heat

569
00:18:26,230 --> 00:18:24,640
that heat holds up the core of the star

570
00:18:28,390 --> 00:18:26,240
and eventually comes out to the surface

571
00:18:30,390 --> 00:18:28,400
and that actually what it comes to earth

572
00:18:32,789 --> 00:18:30,400
now for stars a lot heavier than our sun

573
00:18:34,230 --> 00:18:32,799
so maybe 10 times the mass of our sun

574
00:18:36,070 --> 00:18:34,240
the center of the star can get hot

575
00:18:38,470 --> 00:18:36,080
enough that you can fuse the helium into

576
00:18:41,029 --> 00:18:38,480
carbon nitrogen oxygen finally onto

577
00:18:43,029 --> 00:18:41,039
silicon and iron once you get to iron

578
00:18:44,870 --> 00:18:43,039
the nuclear fusion in the center sort of

579
00:18:46,950 --> 00:18:44,880
takes in energy rather than releasing

580
00:18:48,470 --> 00:18:46,960
energy and so it takes heat away from

581
00:18:50,549 --> 00:18:48,480
the center of the star it can't hold the

582
00:18:52,789 --> 00:18:50,559
star up anymore and the star collapses

583
00:18:54,710 --> 00:18:52,799
when that happens eventually it explodes

584
00:18:56,789 --> 00:18:54,720
in something called a supernova

585
00:18:58,390 --> 00:18:56,799
now this is an important question for

586
00:19:00,310 --> 00:18:58,400
for us because it answers one of the key

587
00:19:02,230 --> 00:19:00,320
fundamental questions of nasa that nasa

588
00:19:05,190 --> 00:19:02,240

wants to answer which is how did we get

589
00:19:08,070 --> 00:19:05,200
here right supernovae see the universe

590
00:19:10,710 --> 00:19:08,080
with heavy elements that make stars like

591
00:19:12,710 --> 00:19:10,720
our sun planets like earth and people

592
00:19:14,549 --> 00:19:12,720
like us so we really would like to

593
00:19:16,390 --> 00:19:14,559
understand how these massive stars

594
00:19:18,230 --> 00:19:16,400
explode in order to get a better

595
00:19:19,669 --> 00:19:18,240
understanding about how the universe

596
00:19:20,710 --> 00:19:19,679
came to be

597
00:19:23,350 --> 00:19:20,720
now

598
00:19:26,630 --> 00:19:25,190
there's a way that nustar helps uh

599
00:19:28,230 --> 00:19:26,640
figure this out which i'm going to tell

600
00:19:29,669 --> 00:19:28,240
you about in a second here

601
00:19:31,270 --> 00:19:29,679
so

602
00:19:32,549 --> 00:19:31,280
yeah i have to start ask to start

603
00:19:37,830 --> 00:19:32,559
collapses

604
00:19:40,230 --> 00:19:37,840
um sort of what happens is you get this

605
00:19:42,630 --> 00:19:40,240
compression of the center of the star

606
00:19:44,390 --> 00:19:42,640
um and you what we think happens you get

607
00:19:45,990 --> 00:19:44,400
sort of bubbles of a mater material at

608
00:19:47,510 --> 00:19:46,000
the very center of the star

609
00:19:48,710 --> 00:19:47,520
um the rest of the star is acting kind

610
00:19:50,710 --> 00:19:48,720
of like a pressure cooker so it's

611
00:19:52,230 --> 00:19:50,720
pushing in from all sides and what these

612
00:19:53,590 --> 00:19:52,240
bubbles do is it kind of poke through

613
00:19:55,590 --> 00:19:53,600

the holes in the pressure cooker which

614
00:19:56,950 --> 00:19:55,600
rips the star apart and blows the whole

615
00:19:58,710 --> 00:19:56,960
thing up

616
00:20:00,710 --> 00:19:58,720
now the way new star gets at this is

617
00:20:02,870 --> 00:20:00,720
there's a very special kind of isotope

618
00:20:05,029 --> 00:20:02,880
of titanium made deep in the core of the

619
00:20:07,830 --> 00:20:05,039
collapsing star that lets us see things

620
00:20:10,710 --> 00:20:07,840
so let's go to image number nine

621
00:20:13,590 --> 00:20:10,720
so this is titanium 44 and the key point

622
00:20:15,510 --> 00:20:13,600
here is that titanium 44 is radioactive

623
00:20:17,430 --> 00:20:15,520
which means it doesn't like to stay as

624
00:20:20,390 --> 00:20:17,440
titanium 44. it's got a half-life of

625
00:20:22,710 --> 00:20:20,400
about 60 years after which it splits and

626
00:20:25,110 --> 00:20:22,720
eventually ends up as calcium 44. and

627
00:20:28,149 --> 00:20:25,120
when it does that it releases a bunch of

628
00:20:29,830 --> 00:20:28,159
gamma rays and x-rays at very particular

629
00:20:31,669 --> 00:20:29,840
energies or colors

630
00:20:34,070 --> 00:20:31,679
so the two on the right there at 68 and

631
00:20:35,669 --> 00:20:34,080
78 kev kev is an x-ray unit you just

632
00:20:36,950 --> 00:20:35,679
think of them as colors

633
00:20:39,350 --> 00:20:36,960
those are the ones that nustar was

634
00:20:41,350 --> 00:20:39,360
actually designed to go observe

635
00:20:43,750 --> 00:20:41,360
now unlike other elements in the star

636
00:20:45,350 --> 00:20:43,760
the radio material glows on its own so

637
00:20:46,710 --> 00:20:45,360
the rest of the stuff in the star you

638
00:20:48,230 --> 00:20:46,720

only see

639
00:20:50,470 --> 00:20:48,240
when it's shock heated and you can think

640
00:20:51,669 --> 00:20:50,480
of thinking back to the neon bulb if you

641
00:20:53,270 --> 00:20:51,679
just have the neon bulb sitting there

642
00:20:56,070 --> 00:20:53,280
with no voltage across it it doesn't do

643
00:20:57,590 --> 00:20:56,080
anything when you turn on the the switch

644
00:20:59,430 --> 00:20:57,600
and you turn on the voltage then you see

645
00:21:01,430 --> 00:20:59,440
the neon emission same thing kind of

646
00:21:02,789 --> 00:21:01,440
happens in a supernova uh in a supernova

647
00:21:04,870 --> 00:21:02,799
remnant sort of the dead body that's

648
00:21:07,190 --> 00:21:04,880
left behind by the exploding star the

649
00:21:08,950 --> 00:21:07,200
shot goes out and energizes a lot of the

650
00:21:09,750 --> 00:21:08,960
material and that actually lets you see

651
00:21:18,230 --> 00:21:09,760
it

652
00:21:19,909 --> 00:21:18,240
radioactive

653
00:21:21,990 --> 00:21:19,919
so it gives you a pure tracer of the

654
00:21:24,070 --> 00:21:22,000
radioactive ash and the reason it's

655
00:21:26,149 --> 00:21:24,080
important is uh isotope is it's actually

656
00:21:28,549 --> 00:21:26,159
created way down deep in the center of

657
00:21:30,870 --> 00:21:28,559
the star so it's tracing out these

658
00:21:32,549 --> 00:21:30,880
bubbles uh of that that might be

659
00:21:34,149 --> 00:21:32,559
occurring in the center of the explosion

660
00:21:36,470 --> 00:21:34,159
and then you can go sort of like a csi

661
00:21:37,750 --> 00:21:36,480
detective later look at what's left on

662
00:21:39,669 --> 00:21:37,760
this on the sky and try to figure out

663
00:21:42,070 --> 00:21:39,679

what happened in the explosion

664
00:21:43,669 --> 00:21:42,080
so let's go to image number 10.

665
00:21:46,230 --> 00:21:43,679
all right so this is my favorite

666
00:21:48,470 --> 00:21:46,240
supernova remnant this is cassiopeia a

667
00:21:51,270 --> 00:21:48,480
uh this is the leftover body of a star

668
00:21:53,510 --> 00:21:51,280
that blew up in about 1680.

669
00:21:55,669 --> 00:21:53,520
and this is uh actually exactly what our

670
00:21:58,549 --> 00:21:55,679
our color our chat asked about a second

671
00:22:00,310 --> 00:21:58,559
ago this is a false color image mixing

672
00:22:03,190 --> 00:22:00,320
data from the chandra x-ray telescope

673
00:22:05,350 --> 00:22:03,200
and nustar so in chandra we're looking

674
00:22:06,950 --> 00:22:05,360
at emission from iron which we've

675
00:22:08,710 --> 00:22:06,960
colored red here

676
00:22:11,029 --> 00:22:08,720
silicon and magnesium which we're

677
00:22:12,950 --> 00:22:11,039
coloring green and the rest of the the

678
00:22:15,430 --> 00:22:12,960
shock emission which is in gold

679
00:22:17,990 --> 00:22:15,440
now the blue here is the titanium 44

680
00:22:19,430 --> 00:22:18,000
observed by nustar now this is way above

681
00:22:21,990 --> 00:22:19,440
the ability of any other focusing

682
00:22:24,070 --> 00:22:22,000
instrument to to see it's way beyond

683
00:22:25,270 --> 00:22:24,080
what chandra and x-men can do

684
00:22:26,710 --> 00:22:25,280
so this is the first time we've ever

685
00:22:28,070 --> 00:22:26,720
sort of seen an image of what the

686
00:22:29,669 --> 00:22:28,080
titanium looked like and the minute we

687
00:22:32,230 --> 00:22:29,679
looked at it we were like okay what's

688
00:22:33,350 --> 00:22:32,240

going on here so the

689
00:22:37,909 --> 00:22:33,360
you know

690
00:22:40,070 --> 00:22:37,919
sort of could have been just very smooth

691
00:22:42,070 --> 00:22:40,080
uh just a spherical isotropic explosion

692
00:22:44,149 --> 00:22:42,080
it's not right clearly we can see that

693
00:22:46,230 --> 00:22:44,159
the blue is nice and clumpy we can

694
00:22:48,310 --> 00:22:46,240
actually trace the doppler shifts of the

695
00:22:50,149 --> 00:22:48,320
blue light uh sort of like a siren

696
00:22:52,149 --> 00:22:50,159
coming by you uh changing pitch as it

697
00:22:53,909 --> 00:22:52,159
goes uh towards you and away from you

698
00:22:55,590 --> 00:22:53,919
and actually get a 3d reconstruction of

699
00:22:57,669 --> 00:22:55,600
what's going on in the supernova remnant

700
00:22:59,270 --> 00:22:57,679
and we tell it there's giant asymmetries

701
00:23:01,270 --> 00:22:59,280
there's more stuff moving away from us

702
00:23:03,830 --> 00:23:01,280
than towards us um so it was really an

703
00:23:05,350 --> 00:23:03,840
exciting uh first light kind of thing

704
00:23:06,950 --> 00:23:05,360
where we got to go look at the suit at

705
00:23:08,470 --> 00:23:06,960
the supernova remnant

706
00:23:09,990 --> 00:23:08,480
now before we launched we knew we were

707
00:23:11,350 --> 00:23:10,000
going to do this right you tell nasa i

708
00:23:12,230 --> 00:23:11,360
want to build this new satellite they

709
00:23:14,390 --> 00:23:12,240
say okay well what are you going to do

710
00:23:15,830 --> 00:23:14,400
with it cassay is one of the things we

711
00:23:18,070 --> 00:23:15,840
we said okay we're going to go look at

712
00:23:20,230 --> 00:23:18,080
the titanium and cassay and it's going

713
00:23:21,350 --> 00:23:20,240

to either look like a nice vertical ball

714
00:23:22,870 --> 00:23:21,360
or it's going to look like the iron

715
00:23:24,710 --> 00:23:22,880
emission or it's going to look like the

716
00:23:25,750 --> 00:23:24,720
the jet emission that we see here and

717
00:23:27,830 --> 00:23:25,760
obviously it doesn't look like any of

718
00:23:29,750 --> 00:23:27,840
those things right so this was an

719
00:23:32,390 --> 00:23:29,760
exciting uh reason why you know you go

720
00:23:34,149 --> 00:23:32,400
build new observatories to get new data

721
00:23:35,510 --> 00:23:34,159
so you can actually say ah okay we

722
00:23:36,390 --> 00:23:35,520
thought we we knew what was going to

723
00:23:39,430 --> 00:23:36,400
happen here

724
00:23:41,269 --> 00:23:39,440
we were wrong this was a sort of a known

725
00:23:42,630 --> 00:23:41,279
unknown and one of the one of the really

726
00:23:44,310 --> 00:23:42,640
interesting science results from new

727
00:23:45,909 --> 00:23:44,320
star

728
00:23:47,909 --> 00:23:45,919
that's very very cool

729
00:23:49,029 --> 00:23:47,919
um let's check in with chad again mr

730
00:23:51,830 --> 00:23:49,039
white how are we doing out there my

731
00:23:54,630 --> 00:23:51,840
friend such wonderful questions keep

732
00:23:55,990 --> 00:23:54,640
them coming folks um so speaking of new

733
00:23:58,950 --> 00:23:56,000
observatories

734
00:24:00,950 --> 00:23:58,960
baba ganoush on youtube asks with such a

735
00:24:02,950 --> 00:24:00,960
difference in wavelength image how will

736
00:24:05,269 --> 00:24:02,960
nustar be able to partner with the web

737
00:24:08,230 --> 00:24:05,279
telescope and studies to understand high

738
00:24:11,110 --> 00:24:08,240

redshift and high energy objects

739
00:24:13,590 --> 00:24:11,120
so even right now nustar is looking at

740
00:24:15,909 --> 00:24:13,600
some of the fields that james webb will

741
00:24:17,669 --> 00:24:15,919
will look at so there's a fields in the

742
00:24:19,510 --> 00:24:17,679
north ecliptic poll where james webb is

743
00:24:21,750 --> 00:24:19,520
going to look at that a lot to look for

744
00:24:24,310 --> 00:24:21,760
things that are varying and so nustar is

745
00:24:26,149 --> 00:24:24,320
going to find a lot of the black holes

746
00:24:28,310 --> 00:24:26,159
that james webb is actually going to see

747
00:24:29,990 --> 00:24:28,320
and will help characterize those things

748
00:24:31,590 --> 00:24:30,000
so it connects through the infrared

749
00:24:33,029 --> 00:24:31,600
light that james webb is going to see

750
00:24:34,789 --> 00:24:33,039
with the high energy x-rays that new

751
00:24:35,909 --> 00:24:34,799
star sees so we're looking forward to

752
00:24:37,590 --> 00:24:35,919
really working with james webb over the

753
00:24:39,269 --> 00:24:37,600
next few years

754
00:24:40,710 --> 00:24:39,279
well you also said the magic phrase

755
00:24:42,070 --> 00:24:40,720
black holes we've been getting lots of

756
00:24:43,430 --> 00:24:42,080
great questions about black holes and

757
00:24:45,909 --> 00:24:43,440
maybe this can lead you down your next

758
00:24:47,830 --> 00:24:45,919
path i'm going to combine two here so

759
00:24:50,549 --> 00:24:47,840
raoul on facebook

760
00:24:53,190 --> 00:24:50,559
asks could similar techniques be used to

761
00:24:55,430 --> 00:24:53,200
make an image of a black hole in x-ray

762
00:24:57,669 --> 00:24:55,440
like the one used in the eht using a

763
00:25:00,870 --> 00:24:57,679

different x-ray observatories and then

764
00:25:02,390 --> 00:25:00,880
tom on youtube asks do black holes emit

765
00:25:05,430 --> 00:25:02,400
x-rays

766
00:25:06,870 --> 00:25:05,440
so the first the answer to the ehd

767
00:25:08,549 --> 00:25:06,880
question is

768
00:25:10,070 --> 00:25:08,559
i don't know

769
00:25:13,190 --> 00:25:10,080
which is i think of a very fair answer

770
00:25:14,950 --> 00:25:13,200
so the eht was mostly radio telescopes

771
00:25:17,830 --> 00:25:14,960
you can merge them together using

772
00:25:20,070 --> 00:25:17,840
interferometry in a very complex way

773
00:25:21,830 --> 00:25:20,080
it would be very difficult to do that in

774
00:25:23,669 --> 00:25:21,840
x-rays and certainly beyond the

775
00:25:26,070 --> 00:25:23,679
capabilities of what we have now

776
00:25:27,430 --> 00:25:26,080
um the second question of what we see

777
00:25:28,470 --> 00:25:27,440
you know do we see x-rays from black

778
00:25:33,029 --> 00:25:28,480
holes

779
00:25:34,470 --> 00:25:33,039
don't emit x-rays but as they eat

780
00:25:36,070 --> 00:25:34,480
material which i'm going to get to in

781
00:25:39,029 --> 00:25:36,080
just a second here they can actually

782
00:25:41,909 --> 00:25:39,039
re-emit uh that uh gravitational energy

783
00:25:44,470 --> 00:25:41,919
out as x-rays and my office mate does a

784
00:25:46,470 --> 00:25:44,480
lot of amazing work studying the the

785
00:25:49,909 --> 00:25:46,480
extreme gravity right near the edge of

786
00:25:53,190 --> 00:25:51,590
wonderful uh we'll keep those questions

787
00:25:54,310 --> 00:25:53,200
coming folks we're going to keep get it

788
00:25:58,149 --> 00:25:54,320

we're going to get as many in as we

789
00:26:02,870 --> 00:25:59,830
all right so um

790
00:26:04,070 --> 00:26:02,880
yeah sorry sorry sorry mark uh

791
00:26:05,750 --> 00:26:04,080
yeah i was just i wanted to tell you

792
00:26:07,510 --> 00:26:05,760
guys another story um

793
00:26:09,430 --> 00:26:07,520
and uh it sort of starts with one of my

794
00:26:11,510 --> 00:26:09,440
favorite quotes which i'm pretty sure is

795
00:26:13,510 --> 00:26:11,520
is from isaac asimov which goes that the

796
00:26:14,710 --> 00:26:13,520
most exciting phrase in science is not

797
00:26:16,710 --> 00:26:14,720
eureka

798
00:26:18,230 --> 00:26:16,720
but okay that's funny

799
00:26:20,310 --> 00:26:18,240
um so we had one of those moments a

800
00:26:22,310 --> 00:26:20,320
couple years ago so there are these

801
00:26:25,190 --> 00:26:22,320
objects called ultraluminous x-ray

802
00:26:26,390 --> 00:26:25,200
sources or ulx's these things are so

803
00:26:28,390 --> 00:26:26,400
bright that we can see them in other

804
00:26:30,310 --> 00:26:28,400
galaxies and they're so bright in fact

805
00:26:32,470 --> 00:26:30,320
that people generally assume they had to

806
00:26:34,710 --> 00:26:32,480
be black holes and not just black holes

807
00:26:36,470 --> 00:26:34,720
but big black holes so let me let me

808
00:26:37,750 --> 00:26:36,480
sort of give you a reason why we think

809
00:26:40,390 --> 00:26:37,760
that's the case let's bring up image

810
00:26:43,990 --> 00:26:41,669
uh

811
00:26:45,430 --> 00:26:44,000
i think we there we go great um so this

812
00:26:47,110 --> 00:26:45,440
is a little cartoon

813
00:26:49,269 --> 00:26:47,120

that shows what happens when a material

814
00:26:51,430 --> 00:26:49,279
falls into a black hole

815
00:26:53,590 --> 00:26:51,440
so as material falls in

816
00:26:56,630 --> 00:26:53,600
it gets converted from gravitational

817
00:26:58,230 --> 00:26:56,640
energy into radiation that equals mc

818
00:27:00,070 --> 00:26:58,240
squared thing

819
00:27:02,230 --> 00:27:00,080
and some of the some of the energy sort

820
00:27:04,789 --> 00:27:02,240
of gets emitted out as light

821
00:27:06,710 --> 00:27:04,799
and that provides sort of a pressure

822
00:27:08,310 --> 00:27:06,720
against the material that's falling in

823
00:27:10,470 --> 00:27:08,320
so there is

824
00:27:12,149 --> 00:27:10,480
effectively a maximum amount that a

825
00:27:13,430 --> 00:27:12,159
black hole can eat black holes are on

826
00:27:15,029 --> 00:27:13,440
diet

827
00:27:16,630 --> 00:27:15,039
so when you hit a balance you hit

828
00:27:18,389 --> 00:27:16,640
something called the eddington limit

829
00:27:20,470 --> 00:27:18,399
where you start you simply can't put any

830
00:27:22,149 --> 00:27:20,480
more matter into the black hole and

831
00:27:23,029 --> 00:27:22,159
therefore you can't get any more light

832
00:27:25,110 --> 00:27:23,039
out

833
00:27:26,950 --> 00:27:25,120
so what this means is when you have a

834
00:27:28,950 --> 00:27:26,960
black hole you can sort of scale it if i

835
00:27:31,029 --> 00:27:28,960
if i turn the mass of the black hole up

836
00:27:33,190 --> 00:27:31,039
i can throw more material in there which

837
00:27:34,710 --> 00:27:33,200
means i can generate more light so if i

838
00:27:36,630 --> 00:27:34,720

have a heavier black hole you can get

839
00:27:37,669 --> 00:27:36,640
more x-rays a lighter black hole less

840
00:27:39,830 --> 00:27:37,679
x-rays

841
00:27:42,070 --> 00:27:39,840
so for you alex's they were so bright

842
00:27:44,070 --> 00:27:42,080
that people debated for decades about

843
00:27:46,149 --> 00:27:44,080
whether or not they were black holes

844
00:27:47,590 --> 00:27:46,159
sort of in the 10 to 100 times the mass

845
00:27:49,830 --> 00:27:47,600
of our sun eating right at this

846
00:27:51,350 --> 00:27:49,840
eddington limit as fast as they can and

847
00:27:53,430 --> 00:27:51,360
being as bright in the x-rays as they

848
00:27:54,950 --> 00:27:53,440
could be or if they were much bigger

849
00:27:57,669 --> 00:27:54,960
black holes like a thousand times the

850
00:27:59,430 --> 00:27:57,679
mass of our sun eating more moderately

851
00:28:00,870 --> 00:27:59,440
either way generally thought these have

852
00:28:03,510 --> 00:28:00,880
to be black holes

853
00:28:05,190 --> 00:28:03,520
so let's fast forward to january 2014

854
00:28:07,350 --> 00:28:05,200
uh the whole new star science team is in

855
00:28:08,789 --> 00:28:07,360
new york it's freezing we're getting

856
00:28:10,710 --> 00:28:08,799
together to talk about the first year

857
00:28:12,149 --> 00:28:10,720
and a half of amazing results i think i

858
00:28:14,789 --> 00:28:12,159
presented the case results for the first

859
00:28:16,710 --> 00:28:14,799
time at that meeting uh and a supernova

860
00:28:19,269 --> 00:28:16,720
goes off in the galaxy next door so

861
00:28:21,590 --> 00:28:19,279
let's go to image number 12.

862
00:28:23,190 --> 00:28:21,600
there we go so this is the closest

863
00:28:26,470 --> 00:28:23,200

supernova that happened to earth in

864
00:28:28,070 --> 00:28:26,480
decades so this is a galaxy called m82

865
00:28:30,149 --> 00:28:28,080
which is absolutely gorgeous it's called

866
00:28:32,470 --> 00:28:30,159
the cigar galaxy you can see it with

867
00:28:34,389 --> 00:28:32,480
your backyard telescope it's fantastic

868
00:28:35,669 --> 00:28:34,399
um everyone yes we're at the science

869
00:28:37,750 --> 00:28:35,679
team meeting everyone's email starts

870
00:28:40,789 --> 00:28:37,760
exploding saying this thing's happening

871
00:28:41,669 --> 00:28:40,799
uh in m82 so everyone

872
00:28:43,510 --> 00:28:41,679
turned around and pointed their

873
00:28:45,669 --> 00:28:43,520
telescopes at this galaxy for about a

874
00:28:47,909 --> 00:28:45,679
month to try to see any x-rays that

875
00:28:49,350 --> 00:28:47,919
might be coming from the supernova now

876
00:28:52,149 --> 00:28:49,360
unfortunately nustar didn't see a lot

877
00:28:54,310 --> 00:28:52,159
from the supernova itself but we did see

878
00:28:56,389 --> 00:28:54,320
were these x-rays from these two ulx's

879
00:28:58,310 --> 00:28:56,399
that live in this galaxy now we knew

880
00:28:59,269 --> 00:28:58,320
these these yolks's were there from from

881
00:29:01,909 --> 00:28:59,279
before

882
00:29:05,190 --> 00:29:01,919
uh and uh my friend mateo um decided to

883
00:29:06,950 --> 00:29:05,200
go make uh lemonade from lemons and uh

884
00:29:08,470 --> 00:29:06,960
see if there was anything interesting

885
00:29:10,389 --> 00:29:08,480
happening and we had this month-long

886
00:29:12,149 --> 00:29:10,399
data set from these ulx's

887
00:29:13,909 --> 00:29:12,159
and black holes as they're eating stuff

888
00:29:16,389 --> 00:29:13,919

they can have this little uh flickering

889
00:29:18,310 --> 00:29:16,399
behavior that tells you a lot about the

890
00:29:20,389 --> 00:29:18,320
uh geometry of the stuff that's that's

891
00:29:22,789 --> 00:29:20,399
falling into the black hole mateo and

892
00:29:24,710 --> 00:29:22,799
this uh shows up as little variations in

893
00:29:26,149 --> 00:29:24,720
the light curve sort of you can see the

894
00:29:27,430 --> 00:29:26,159
the black hole basically flickering in

895
00:29:29,190 --> 00:29:27,440
x-rays

896
00:29:32,149 --> 00:29:29,200
so he went to look for this stuff

897
00:29:34,230 --> 00:29:32,159
and instead found pulsations

898
00:29:35,909 --> 00:29:34,240
so we're not just pulsations but enough

899
00:29:39,350 --> 00:29:35,919
data to figure out there was a pulsar

900
00:29:40,870 --> 00:29:39,360
that was orbiting something else

901
00:29:42,870 --> 00:29:40,880
you and i talked about this before that

902
00:29:44,389 --> 00:29:42,880
was a big deal right and you guys

903
00:29:46,389 --> 00:29:44,399
discovered that yeah this is this is

904
00:29:47,669 --> 00:29:46,399
kind of a huge deal because black holes

905
00:29:49,430 --> 00:29:47,679
can't pulse

906
00:29:50,950 --> 00:29:49,440
in order to get something to pulse you

907
00:29:52,310 --> 00:29:50,960
need a hot spot that's spinning around

908
00:29:53,590 --> 00:29:52,320
it's sort of like a lighthouse beaming

909
00:29:55,430 --> 00:29:53,600
through the universe

910
00:29:57,190 --> 00:29:55,440
but you need a surface you need a

911
00:29:59,110 --> 00:29:57,200
surface that's creating some you know

912
00:30:02,310 --> 00:29:59,120
temperature and black holes don't have a

913
00:30:03,750 --> 00:30:02,320

surface so no hot spots no pulsations so

914
00:30:05,909 --> 00:30:03,760
all of a sudden the whole black hole

915
00:30:08,070 --> 00:30:05,919
idea that these ulx's were black holes

916
00:30:09,990 --> 00:30:08,080
are out the door so instead we think

917
00:30:11,510 --> 00:30:10,000
there's actually a neutron star so not

918
00:30:13,990 --> 00:30:11,520
something a thousand times the mass of

919
00:30:15,510 --> 00:30:14,000
our sun not 10 times the mass of our sun

920
00:30:17,669 --> 00:30:15,520
something that's basically only maybe

921
00:30:19,269 --> 00:30:17,679
one or two times the mass of our sun

922
00:30:22,149 --> 00:30:19,279
crammed into the same space as san

923
00:30:24,070 --> 00:30:22,159
francisco and this thing was spinning

924
00:30:25,750 --> 00:30:24,080
once every two seconds and orbiting its

925
00:30:26,710 --> 00:30:25,760
companion star once every two and a half

926
00:30:29,510 --> 00:30:26,720
days

927
00:30:31,110 --> 00:30:29,520
so let's go to image number 13.

928
00:30:32,950 --> 00:30:31,120
so this is an artist's impression of

929
00:30:35,590 --> 00:30:32,960
what that system might look like you've

930
00:30:37,990 --> 00:30:35,600
got a this is a binary system so you

931
00:30:40,310 --> 00:30:38,000
have the neutron star there orbiting a

932
00:30:42,389 --> 00:30:40,320
big star it's eating material from the

933
00:30:44,549 --> 00:30:42,399
big star you've got this big accretion

934
00:30:45,750 --> 00:30:44,559
disk of material this pancake as the

935
00:30:47,909 --> 00:30:45,760
materials flowing in and then the

936
00:30:50,230 --> 00:30:47,919
neutron star sitting there at the center

937
00:30:52,630 --> 00:30:50,240
so this is now an entirely new field of

938
00:30:55,430 --> 00:30:52,640

astronomy because we had this unique

939
00:30:56,870 --> 00:30:55,440
data set of uh from these ulx's because

940
00:30:59,190 --> 00:30:56,880
we had a month of data we could actually

941
00:31:00,310 --> 00:30:59,200
go find the pulsations from these things

942
00:31:01,750 --> 00:31:00,320
and now we know that they're way

943
00:31:04,149 --> 00:31:01,760
brighter than they should be based on

944
00:31:05,269 --> 00:31:04,159
that any team limit so there's really

945
00:31:06,870 --> 00:31:05,279
you know

946
00:31:08,789 --> 00:31:06,880
we have no idea how these things are

947
00:31:10,549 --> 00:31:08,799
actually uh emitting this much x-ray

948
00:31:11,509 --> 00:31:10,559
light it's a really really exciting

949
00:31:13,269 --> 00:31:11,519
result

950
00:31:15,669 --> 00:31:13,279
that's that's so cool like 10 years in

951
00:31:17,750 --> 00:31:15,679
and you've got a whole new field

952
00:31:19,830 --> 00:31:17,760
to play with that's awesome

953
00:31:21,110 --> 00:31:19,840
so what's the future of the spacecraft

954
00:31:23,110 --> 00:31:21,120
look like

955
00:31:24,789 --> 00:31:23,120
so new stars future was really bright um

956
00:31:26,789 --> 00:31:24,799
so the observatory is completely

957
00:31:29,029 --> 00:31:26,799
solar-powered um so as long as we're

958
00:31:30,389 --> 00:31:29,039
flying we're doing great science so i

959
00:31:32,549 --> 00:31:30,399
mentioned the mission operations team at

960
00:31:35,509 --> 00:31:32,559
uc berkeley new star is an entirely

961
00:31:37,669 --> 00:31:35,519
robotic observatory so we send up a set

962
00:31:38,950 --> 00:31:37,679
of commands to tell the telescope where

963
00:31:41,269 --> 00:31:38,960

to look in the sky

964
00:31:43,590 --> 00:31:41,279
um and it goes and does that we observe

965
00:31:44,950 --> 00:31:43,600
24 hours a day seven days a week

966
00:31:46,470 --> 00:31:44,960
we're still making new discoveries and

967
00:31:48,549 --> 00:31:46,480
learning how you know new ways to use

968
00:31:49,590 --> 00:31:48,559
the telescope even now which is

969
00:31:50,710 --> 00:31:49,600
fantastic

970
00:31:52,549 --> 00:31:50,720
there's lots of new and exciting things

971
00:31:55,110 --> 00:31:52,559
for new start to do in the future as

972
00:31:56,470 --> 00:31:55,120
even more new telescopes come online new

973
00:31:58,630 --> 00:31:56,480
star plays really well with others

974
00:32:00,149 --> 00:31:58,640
there's a new mission from nasa called

975
00:32:01,669 --> 00:32:00,159
xp where we're doing a lot of

976
00:32:03,269 --> 00:32:01,679
observations with right now that's

977
00:32:05,190 --> 00:32:03,279
really exciting and there's a new

978
00:32:06,470 --> 00:32:05,200
mission uh that's coming out next year

979
00:32:08,389 --> 00:32:06,480
called chrism that we're also really

980
00:32:10,389 --> 00:32:08,399
looking forward to working with

981
00:32:12,070 --> 00:32:10,399
now one thing you may not know is that

982
00:32:13,269 --> 00:32:12,080
for the most part satellites like nustar

983
00:32:15,110 --> 00:32:13,279
are there for the entire scientific

984
00:32:16,789 --> 00:32:15,120
community to use so after the first

985
00:32:19,110 --> 00:32:16,799
couple years of the mission where we did

986
00:32:20,789 --> 00:32:19,120
all of the stuff that we told nasa we do

987
00:32:22,870 --> 00:32:20,799
with the telescope we sort of turned it

988
00:32:24,470 --> 00:32:22,880

over to the scientific community

989
00:32:26,070 --> 00:32:24,480
most of the observations we do now are

990
00:32:28,070 --> 00:32:26,080
actually from scientists who are not

991
00:32:29,669 --> 00:32:28,080
part of the original science team and it

992
00:32:31,430 --> 00:32:29,679
means that missions like nustar remain

993
00:32:33,509 --> 00:32:31,440
really agile and that we can pivot to

994
00:32:35,269 --> 00:32:33,519
new fields like ultra limited pulsars as

995
00:32:36,710 --> 00:32:35,279
soon as they're discovered so we do this

996
00:32:38,870 --> 00:32:36,720
kind of thing every year and it really

997
00:32:40,149 --> 00:32:38,880
keeps the observatory fresh

998
00:32:41,830 --> 00:32:40,159
that's cool

999
00:32:43,590 --> 00:32:41,840
so what's your role going to be as the

1000
00:32:45,430 --> 00:32:43,600
mission kind of continues through the

1001
00:32:47,830 --> 00:32:45,440
future

1002
00:32:49,669 --> 00:32:47,840
so one of the things i do now is uh you

1003
00:32:51,830 --> 00:32:49,679
know my job is to try to make new star

1004
00:32:53,830 --> 00:32:51,840
as accessible as possible so the great

1005
00:32:56,149 --> 00:32:53,840
thing about x-ray astronomy is that you

1006
00:32:58,070 --> 00:32:56,159
can do it from anywhere you know i do it

1007
00:33:00,630 --> 00:32:58,080
on i make pictures of dead stars on my

1008
00:33:02,310 --> 00:33:00,640
laptop all of the data from nasa

1009
00:33:04,630 --> 00:33:02,320
telescopes are out there in the public

1010
00:33:06,470 --> 00:33:04,640
domain for anyone to use

1011
00:33:08,470 --> 00:33:06,480
we make all of the software publicly

1012
00:33:10,950 --> 00:33:08,480
available most of the developers working

1013
00:33:12,230 --> 00:33:10,960

in astronomy now are working uh in an

1014
00:33:13,509 --> 00:33:12,240
open source environment and so we're

1015
00:33:15,269 --> 00:33:13,519
really trying to encourage a lot of

1016
00:33:17,590 --> 00:33:15,279
people from all over the world to get

1017
00:33:18,710 --> 00:33:17,600
involved uh working with nustar um so

1018
00:33:21,029 --> 00:33:18,720
that's that's one of the things that i

1019
00:33:23,190 --> 00:33:21,039
really like to do um and let's bring up

1020
00:33:25,430 --> 00:33:23,200
image number 14.

1021
00:33:26,710 --> 00:33:25,440
so this is uh this is the new star

1022
00:33:28,389 --> 00:33:26,720
science teams is actually from new

1023
00:33:29,830 --> 00:33:28,399
star's eighth birthday so a couple years

1024
00:33:31,669 --> 00:33:29,840
ago back when playing with zoom

1025
00:33:33,750 --> 00:33:31,679
backgrounds was still a fun thing to do

1026
00:33:36,230 --> 00:33:33,760
um and we had everyone this is just the

1027
00:33:37,750 --> 00:33:36,240
the local caltech and jpl group everyone

1028
00:33:39,509 --> 00:33:37,760
put their favorite science result from

1029
00:33:40,630 --> 00:33:39,519
new star as their background

1030
00:33:42,549 --> 00:33:40,640
and the thing i want to call out here

1031
00:33:43,269 --> 00:33:42,559
actually is that there's you know a lot

1032
00:33:44,789 --> 00:33:43,279
of

1033
00:33:46,870 --> 00:33:44,799
undergrads and even high school students

1034
00:33:47,990 --> 00:33:46,880
who come work with us uh x-ray astronomy

1035
00:33:50,310 --> 00:33:48,000
is a great way for people to get

1036
00:33:53,110 --> 00:33:50,320
involved in astronomy and it's really

1037
00:33:56,230 --> 00:33:53,120
been an exciting thing to work on

1038
00:33:57,590 --> 00:33:56,240

that's that's just so cool um and i know

1039
00:33:59,110 --> 00:33:57,600
we could talk about this thing all night

1040
00:34:00,710 --> 00:33:59,120
long but we just unfortunately don't

1041
00:34:03,430 --> 00:34:00,720
have the time but let's check in with uh

1042
00:34:05,830 --> 00:34:03,440
mr white again for questions

1043
00:34:07,110 --> 00:34:05,840
of course um something else that you

1044
00:34:08,790 --> 00:34:07,120
should be aware of that's getting lots

1045
00:34:10,389 --> 00:34:08,800
of congratulations in the chat about the

1046
00:34:12,550 --> 00:34:10,399
length of new stars

1047
00:34:17,829 --> 00:34:12,560
missions so people are cheering for you

1048
00:34:19,829 --> 00:34:17,839
now um luth on youtube asks how intense

1049
00:34:21,990 --> 00:34:19,839
do the source of x-rays have to be to be

1050
00:34:23,750 --> 00:34:22,000
able to detect them

1051
00:34:27,190 --> 00:34:23,760
that's a

1052
00:34:28,629 --> 00:34:27,200
because it depends a lot on how far away

1053
00:34:31,030 --> 00:34:28,639
something is

1054
00:34:32,950 --> 00:34:31,040
so for example when we look at the sun

1055
00:34:34,550 --> 00:34:32,960
nustar is actually the most sensitive

1056
00:34:36,310 --> 00:34:34,560
hard x-ray telescope

1057
00:34:38,389 --> 00:34:36,320
that exists right now to look at the sun

1058
00:34:40,230 --> 00:34:38,399
but that's because it's so close

1059
00:34:41,829 --> 00:34:40,240
if i took the sun and i put it you know

1060
00:34:43,829 --> 00:34:41,839
at the nearest star system at proxima

1061
00:34:45,349 --> 00:34:43,839
centauri those giant solar flares would

1062
00:34:49,030 --> 00:34:45,359
be a lot harder to see

1063
00:34:51,109 --> 00:34:49,040

so nustar looks out and we see stars and

1064
00:34:53,430 --> 00:34:51,119
black holes and neutron stars over a

1065
00:34:55,030 --> 00:34:53,440
whole range of distances so it's really

1066
00:34:57,109 --> 00:34:55,040
something where we can you know it

1067
00:34:59,190 --> 00:34:57,119
depends a lot on how far away something

1068
00:35:01,030 --> 00:34:59,200
is and how hot something is um that

1069
00:35:03,030 --> 00:35:01,040
depends that drives whether or not new

1070
00:35:05,109 --> 00:35:03,040
star can see something

1071
00:35:06,230 --> 00:35:05,119
very cool um

1072
00:35:08,870 --> 00:35:06,240
i swear

1073
00:35:10,870 --> 00:35:08,880
this is another brian who's on facebook

1074
00:35:12,069 --> 00:35:10,880
and they ask and this is a two-part

1075
00:35:14,630 --> 00:35:12,079
question they actually came back to

1076
00:35:17,510 --> 00:35:14,640
elaborate on this the x-ray photons that

1077
00:35:19,030 --> 00:35:17,520
are emitted do they have mass and the

1078
00:35:19,990 --> 00:35:19,040
part that they were a little it's

1079
00:35:22,150 --> 00:35:20,000
difficult to understand what

1080
00:35:25,190 --> 00:35:22,160
electromagnetic energy is if it has no

1081
00:35:28,310 --> 00:35:25,200
mass and can you elaborate on that

1082
00:35:29,349 --> 00:35:28,320
so that is sort of a junior level

1083
00:35:31,510 --> 00:35:29,359
physics

1084
00:35:33,589 --> 00:35:31,520
question um so so

1085
00:35:35,430 --> 00:35:33,599
photons themselves don't have mass but

1086
00:35:37,990 --> 00:35:35,440
they do have momentum and so that's kind

1087
00:35:39,750 --> 00:35:38,000
of a hard hard thing to understand but

1088
00:35:41,670 --> 00:35:39,760

there's an energy density in the

1089
00:35:43,589 --> 00:35:41,680
electromagnetic field that they can

1090
00:35:44,470 --> 00:35:43,599
transmit to matter when they ping off

1091
00:35:46,069 --> 00:35:44,480
something

1092
00:35:47,349 --> 00:35:46,079
so it's it's sort of one of those

1093
00:35:49,349 --> 00:35:47,359
complicated things where you kind of

1094
00:35:52,150 --> 00:35:49,359
have to trust the math um to really

1095
00:35:54,470 --> 00:35:52,160
understand what's going on there

1096
00:35:57,270 --> 00:35:54,480
trust the math very nice um you said you

1097
00:35:58,390 --> 00:35:57,280
you kind of get involved in all parts of

1098
00:35:59,670 --> 00:35:58,400
from beginning to end of all these

1099
00:36:01,829 --> 00:35:59,680
different parts of it

1100
00:36:03,109 --> 00:36:01,839
what this is aaron g on youtube they

1101
00:36:05,030 --> 00:36:03,119
want to know what kind of engineering

1102
00:36:08,630 --> 00:36:05,040
and design goes into building a space

1103
00:36:11,829 --> 00:36:10,550
lots and lots of engineering and design

1104
00:36:13,430 --> 00:36:11,839
this is this is something where we've

1105
00:36:15,349 --> 00:36:13,440
been building these detectors here for

1106
00:36:19,109 --> 00:36:15,359
about 25 years

1107
00:36:21,349 --> 00:36:19,119
um so the uh the basic parts are there's

1108
00:36:22,870 --> 00:36:21,359
uh something that's a lot like the

1109
00:36:24,150 --> 00:36:22,880
camera in your cell phone there's

1110
00:36:25,670 --> 00:36:24,160
something called an asic which is

1111
00:36:27,990 --> 00:36:25,680
electrical engineering there's

1112
00:36:30,630 --> 00:36:28,000
mechanical engineering uh for mounting

1113
00:36:32,790 --> 00:36:30,640

the detectors to the electronics

1114
00:36:34,390 --> 00:36:32,800
uh there's uh crystallography for

1115
00:36:36,470 --> 00:36:34,400
understanding the x-ray crystals you

1116
00:36:37,589 --> 00:36:36,480
actually want to use um and then there's

1117
00:36:39,190 --> 00:36:37,599
all of the parts of putting the whole

1118
00:36:41,349 --> 00:36:39,200
thing together and doing system

1119
00:36:43,430 --> 00:36:41,359
engineering so there's a lot of a lot of

1120
00:36:45,910 --> 00:36:43,440
uh blood sweat and tears that goes into

1121
00:36:46,870 --> 00:36:45,920
making a really good x-ray camera

1122
00:36:48,310 --> 00:36:46,880
all right

1123
00:36:51,030 --> 00:36:48,320
um

1124
00:36:53,030 --> 00:36:51,040
matambale from youtube also asks how do

1125
00:36:55,670 --> 00:36:53,040
you correlate the redshifts between each

1126
00:36:56,950 --> 00:36:55,680
camera when merging images is the shift

1127
00:36:59,109 --> 00:36:56,960
exactly the same between all the

1128
00:37:01,670 --> 00:36:59,119
different scopes

1129
00:37:03,829 --> 00:37:01,680
yes so the two telescopes are

1130
00:37:06,550 --> 00:37:03,839
basically identical um there's you know

1131
00:37:07,670 --> 00:37:06,560
minor variations in how the telescopes

1132
00:37:09,430 --> 00:37:07,680
were built

1133
00:37:11,589 --> 00:37:09,440
but you know they look the exact same

1134
00:37:13,750 --> 00:37:11,599
part of the sky so we can actually use

1135
00:37:15,190 --> 00:37:13,760
the data from the two telescopes as one

1136
00:37:17,430 --> 00:37:15,200
big telescope

1137
00:37:19,589 --> 00:37:17,440
and that's sort of how we actually we

1138
00:37:21,910 --> 00:37:19,599

get more collecting area from the

1139
00:37:23,510 --> 00:37:21,920
telescopes at very high energies all of

1140
00:37:25,510 --> 00:37:23,520
that titanium

1141
00:37:26,710 --> 00:37:25,520
stuff that i showed you was all was the

1142
00:37:28,550 --> 00:37:26,720
data from both telescopes worked

1143
00:37:29,670 --> 00:37:28,560
together

1144
00:37:31,829 --> 00:37:29,680
all right

1145
00:37:34,870 --> 00:37:31,839
we've got time for two more questions so

1146
00:37:37,109 --> 00:37:34,880
mickelson ferry gs on facebook asks how

1147
00:37:39,190 --> 00:37:37,119
is this going to be helpful for

1148
00:37:41,030 --> 00:37:39,200
us here at home

1149
00:37:44,150 --> 00:37:41,040
so one of the fun things about high

1150
00:37:45,990 --> 00:37:44,160
energy astrophysics is it lets you use

1151
00:37:48,390 --> 00:37:46,000
the high the hottest and densest places

1152
00:37:50,390 --> 00:37:48,400
in the universe as laboratories

1153
00:37:52,310 --> 00:37:50,400
uh which you know they're basically

1154
00:37:54,150 --> 00:37:52,320
reproducing stuff or producing

1155
00:37:55,030 --> 00:37:54,160
environments that you can't make here on

1156
00:37:57,190 --> 00:37:55,040
earth

1157
00:37:59,270 --> 00:37:57,200
so one example is looking at neutron

1158
00:38:00,630 --> 00:37:59,280
stars uh neutron stars tell you

1159
00:38:02,630 --> 00:38:00,640
something very fundamental about the

1160
00:38:04,150 --> 00:38:02,640
nature of matter and you simply can't

1161
00:38:05,910 --> 00:38:04,160
make that kind of environment here on

1162
00:38:07,829 --> 00:38:05,920
earth but we have them nature's given us

1163
00:38:09,349 --> 00:38:07,839

laboratories to do this

1164
00:38:11,510 --> 00:38:09,359
similarly there's stuff you can test

1165
00:38:13,430 --> 00:38:11,520
about general relativity and strong

1166
00:38:15,349 --> 00:38:13,440
gravity from looking at the material as

1167
00:38:17,670 --> 00:38:15,359
it falls into a black hole so there's

1168
00:38:19,589 --> 00:38:17,680
all kinds of ways where you can use

1169
00:38:21,030 --> 00:38:19,599
high energy astrophysics as a proxy for

1170
00:38:23,750 --> 00:38:21,040
doing the physics you'd like to do in

1171
00:38:25,349 --> 00:38:23,760
your lab here but you simply can't

1172
00:38:27,270 --> 00:38:25,359
very cool and one of the last questions

1173
00:38:28,950 --> 00:38:27,280
always fun to ask this do you have any

1174
00:38:30,630 --> 00:38:28,960
advice for anybody who wants to get into

1175
00:38:34,069 --> 00:38:30,640
this

1176
00:38:36,230 --> 00:38:34,079
yeah so uh so i started off doing

1177
00:38:37,910 --> 00:38:36,240
astronomy went to physics

1178
00:38:40,150 --> 00:38:37,920
went to high energy astrophysics and

1179
00:38:42,790 --> 00:38:40,160
back to astronomy now i think the the

1180
00:38:46,390 --> 00:38:42,800
major thing to to realize is there's not

1181
00:38:47,750 --> 00:38:46,400
one true way to get from uh if you're in

1182
00:38:49,109 --> 00:38:47,760
high school to get to a point where

1183
00:38:50,230 --> 00:38:49,119
you're gonna be working as a research

1184
00:38:51,829 --> 00:38:50,240
scientist

1185
00:38:53,829 --> 00:38:51,839
a lot of it is following what you're

1186
00:38:55,349 --> 00:38:53,839
interested in and getting involved so

1187
00:38:58,310 --> 00:38:55,359
when i was in high school i got involved

1188
00:38:59,750 --> 00:38:58,320

in the local astronomy club um and uh

1189
00:39:01,829 --> 00:38:59,760
that sort of propagated through when i

1190
00:39:03,990 --> 00:39:01,839
went to college and i got to you know go

1191
00:39:06,470 --> 00:39:04,000
poke around in different labs and really

1192
00:39:07,990 --> 00:39:06,480
get involved uh involved there so i

1193
00:39:09,430 --> 00:39:08,000
would say it's you know taking advantage

1194
00:39:10,630 --> 00:39:09,440
of whatever opportunities you can to

1195
00:39:14,150 --> 00:39:10,640
really get involved and follow the

1196
00:39:15,910 --> 00:39:14,160
things that you're really interested in

1197
00:39:17,750 --> 00:39:15,920
very very cool

1198
00:39:19,430 --> 00:39:17,760
well thank you guys both very much um

1199
00:39:20,710 --> 00:39:19,440
before we wrap it up tonight brian do

1200
00:39:22,310 --> 00:39:20,720
you have any final thoughts for the

1201
00:39:23,750 --> 00:39:22,320
audience

1202
00:39:25,270 --> 00:39:23,760
uh well first i'd like to thank you and

1203
00:39:27,190 --> 00:39:25,280
mark for having me here tonight i've had

1204
00:39:28,710 --> 00:39:27,200
a really good time uh i could literally

1205
00:39:31,109 --> 00:39:28,720
talk for hours about all of this stuff

1206
00:39:33,430 --> 00:39:31,119
and and i have you can ask my friends

1207
00:39:36,069 --> 00:39:33,440
um so uh if you do want to keep up with

1208
00:39:37,829 --> 00:39:36,079
nustar um like brian said uh you can

1209
00:39:39,910 --> 00:39:37,839
find all of this cool stuff that new

1210
00:39:40,630 --> 00:39:39,920
star does on the new star webpage which

1211
00:39:42,710 --> 00:39:40,640
i don't know if we're doing at the

1212
00:39:44,630 --> 00:39:42,720
bottom third or not but it's new start

1213
00:39:46,790 --> 00:39:44,640

at caltech.edu

1214
00:39:48,710 --> 00:39:46,800
so we try to keep that updated with all

1215
00:39:50,230 --> 00:39:48,720
the new results that are coming out we

1216
00:39:51,430 --> 00:39:50,240
also get shout outs from nasa universe

1217
00:39:53,270 --> 00:39:51,440
on twitter

1218
00:39:54,550 --> 00:39:53,280
so you can follow along there and then

1219
00:39:55,990 --> 00:39:54,560
there's a pretty good community of

1220
00:39:58,310 --> 00:39:56,000
astronomers who like to talk about what

1221
00:40:00,230 --> 00:39:58,320
we do on twitter and so if you manage to

1222
00:40:02,150 --> 00:40:00,240
find us then uh we're more than happy to

1223
00:40:03,510 --> 00:40:02,160
talk about all of this stuff uh in the

1224
00:40:04,550 --> 00:40:03,520
future so i hope i've been able to share

1225
00:40:06,150 --> 00:40:04,560
some of my excitement about all the

1226
00:40:08,950 --> 00:40:06,160
stuff with you tonight and i want to

1227
00:40:11,430 --> 00:40:08,960
thank the chat for the great questions

1228
00:40:13,030 --> 00:40:11,440
oh brian seriously thank you for

1229
00:40:14,950 --> 00:40:13,040
you know everything you're sharing your

1230
00:40:16,550 --> 00:40:14,960
knowledge your enthusiasm

1231
00:40:17,829 --> 00:40:16,560
and we're really glad obviously that you

1232
00:40:19,349 --> 00:40:17,839
know you could come and spend some time

1233
00:40:20,790 --> 00:40:19,359
with us tonight so we know it's a bit of

1234
00:40:23,589 --> 00:40:20,800
a commitment so

1235
00:40:25,109 --> 00:40:23,599
again we're grateful um so folks that's

1236
00:40:27,030 --> 00:40:25,119
pretty much all the time we have tonight

1237
00:40:28,470 --> 00:40:27,040
so i want to thank both brian's for all

1238
00:40:29,990 --> 00:40:28,480

their work putting this together the

1239
00:40:32,069 --> 00:40:30,000
crew behind the scenes that make this

1240
00:40:33,670 --> 00:40:32,079
all possible and of course all of you

1241
00:40:36,309 --> 00:40:33,680
for tuning in for your fantastic

1242
00:40:39,030 --> 00:40:36,319
questions tonight so take care

1243
00:40:43,040 --> 00:40:39,040
stay well and we'll see you next month