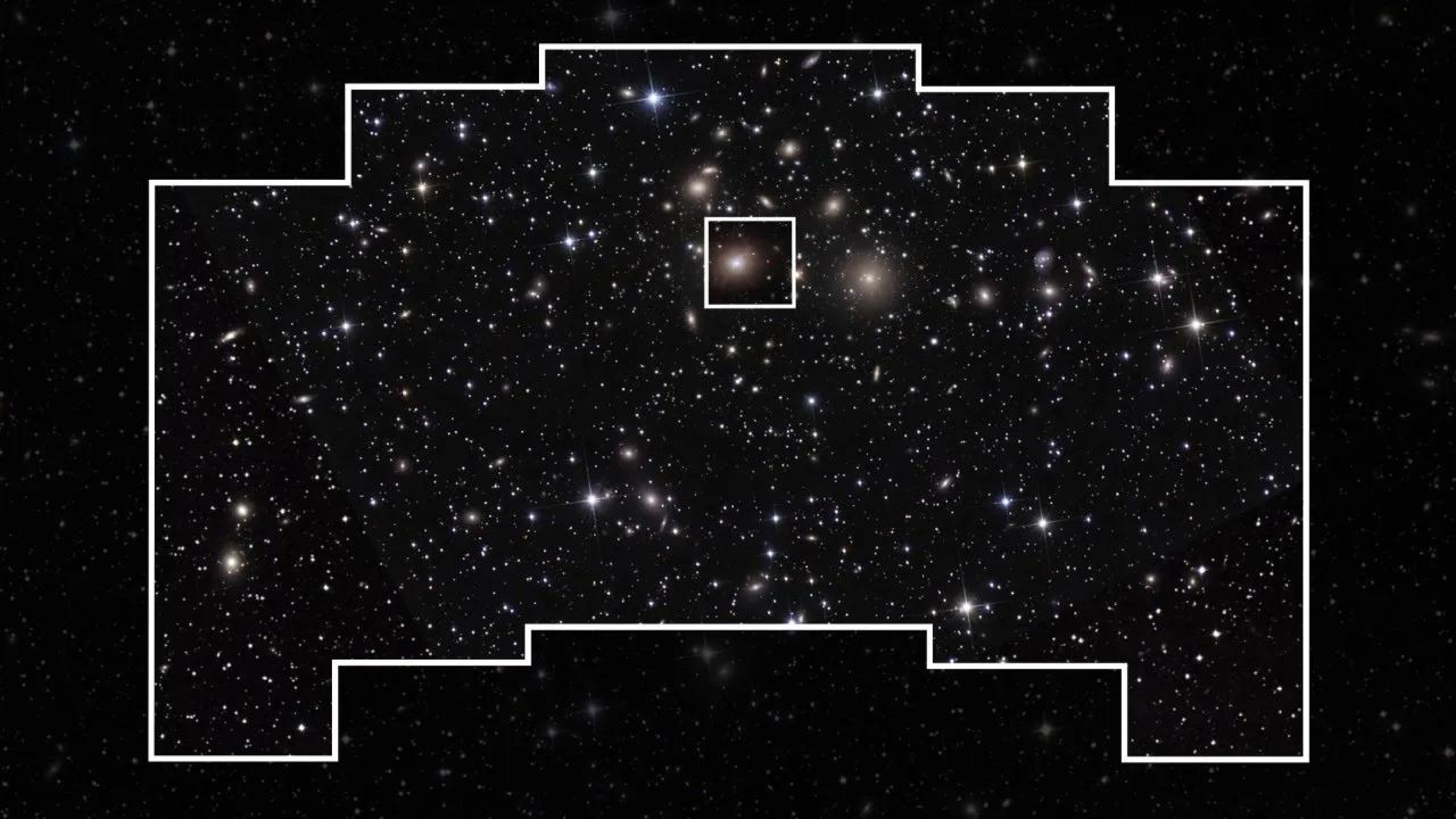

1
00:00:06,070 --> 00:00:04,230
hello everyone

2
00:00:08,549 --> 00:00:06,080
and welcome to the science writers

3
00:00:10,709 --> 00:00:08,559
workshop on the roman space telescope

4
00:00:12,070 --> 00:00:10,719
hosted by the space telescope science

5
00:00:14,070 --> 00:00:12,080
institute

6
00:00:15,509 --> 00:00:14,080
i'm christine pulliam and i'll be your

7
00:00:16,950 --> 00:00:15,519
host

8
00:00:19,109 --> 00:00:16,960
this workshop features a panel of

9
00:00:21,029 --> 00:00:19,119
speakers on a variety of topics

10
00:00:22,790 --> 00:00:21,039
the format of the workshop is that we'll

11
00:00:24,550 --> 00:00:22,800
go through all of the speakers in order

12
00:00:25,910 --> 00:00:24,560
and then open it up to questions and

13
00:00:27,589 --> 00:00:25,920

answers

14
00:00:30,150 --> 00:00:27,599
you can ask questions by typing them

15
00:00:31,349 --> 00:00:30,160
into the youtube chat window

16
00:00:32,709 --> 00:00:31,359
please note that you can type your

17
00:00:34,389 --> 00:00:32,719
questions at any time during this

18
00:00:36,870 --> 00:00:34,399
workshop and we'll work our way through

19
00:00:39,990 --> 00:00:36,880
them during the q a

20
00:00:42,630 --> 00:00:40,000
and now let me introduce our speakers

21
00:00:43,670 --> 00:00:42,640
dr olivia lupe from the nasa goddard

22
00:00:45,670 --> 00:00:43,680
space flight center

23
00:00:47,590 --> 00:00:45,680
will tell us about nancy grace roman and

24
00:00:49,750 --> 00:00:47,600
her legacy

25
00:00:51,430 --> 00:00:49,760
dr julie mcenery from the nasa goddard

26
00:00:53,590 --> 00:00:51,440
space flight center will introduce the

27
00:00:55,189 --> 00:00:53,600
roman space telescope and its wide field

28
00:00:57,270 --> 00:00:55,199
instrument

29
00:00:59,189 --> 00:00:57,280
dr jason rhodes from the nasa jet

30
00:01:01,590 --> 00:00:59,199
propulsion laboratory will introduce the

31
00:01:03,590 --> 00:01:01,600
coronagraph instrument

32
00:01:05,429 --> 00:01:03,600
nobel laureate dr adam reese of the

33
00:01:06,870 --> 00:01:05,439
space telescope science institute and

34
00:01:09,990 --> 00:01:06,880
johns hopkins university

35
00:01:10,550 --> 00:01:10,000
will tell us about the dark universe dr

36
00:01:13,590 --> 00:01:10,560
rachel

37
00:01:15,590 --> 00:01:13,600
institute and

38
00:01:18,149 --> 00:01:15,600

rutgers university will tell us about

39
00:01:20,230 --> 00:01:18,159
galaxies across cosmic time

40
00:01:22,390 --> 00:01:20,240
and dr harry ferguson from the space

41
00:01:22,789 --> 00:01:22,400
telescope science institute will tell us

42
00:01:26,230 --> 00:01:22,799
about

43
00:01:34,550 --> 00:01:26,240
science synergies of the 2020s

44
00:01:52,830 --> 00:01:37,749
thank you christine this is olivia loopy

45
00:02:01,590 --> 00:01:55,030
okay

46
00:02:02,709 --> 00:02:01,600
the page you're good to go very good

47
00:02:04,709 --> 00:02:02,719
thank you very much

48
00:02:06,789 --> 00:02:04,719
i uh i'm honored to be talking about

49
00:02:10,150 --> 00:02:06,799
nancy grace roman

50
00:02:12,630 --> 00:02:10,160
at this workshop and i'm also honored

51
00:02:15,030 --> 00:02:12,640
to be on this panel with with my very

52
00:02:16,710 --> 00:02:15,040
very distinguished colleagues

53
00:02:18,309 --> 00:02:16,720
i'd like to read this to you very

54
00:02:20,070 --> 00:02:18,319
quickly um

55
00:02:22,150 --> 00:02:20,080
we named great things after someone to

56
00:02:24,309 --> 00:02:22,160
honor profound discovery a singular

57
00:02:26,229 --> 00:02:24,319
contribution to a discipline

58
00:02:27,750 --> 00:02:26,239
we named great creations after people

59
00:02:29,830 --> 00:02:27,760
who were trailblazers

60
00:02:32,630 --> 00:02:29,840
the first to achieve a pivotal goal when

61
00:02:34,550 --> 00:02:32,640
conditions were not favorable to do so

62
00:02:36,550 --> 00:02:34,560
when challenges were astronomical they

63
00:02:38,229 --> 00:02:36,560

drove themselves tirelessly to turn

64
00:02:40,470 --> 00:02:38,239
nothing into something

65
00:02:42,309 --> 00:02:40,480
and in doing so they continue to inspire

66
00:02:44,869 --> 00:02:42,319
us they give to us a vision

67
00:02:45,830 --> 00:02:44,879
and they power our hope and when an

68
00:02:47,910 --> 00:02:45,840
esteemed person

69
00:02:49,350 --> 00:02:47,920
achieves these great things but you know

70
00:02:52,070 --> 00:02:49,360
with the gentle

71
00:02:53,750 --> 00:02:52,080
voice with modesty and fairness and when

72
00:02:56,550 --> 00:02:53,760
integrity and passion drive

73
00:02:57,190 --> 00:02:56,560
every action the honor we bestow is deep

74
00:03:02,949 --> 00:02:57,200
seated

75
00:03:07,509 --> 00:03:02,959
and heartfelt dr nancy grace roman

76
00:03:11,670 --> 00:03:07,519
to 1925-2018 and the nancy grace roman

77
00:03:12,550 --> 00:03:11,680
space telescope so who is nancy grace

78
00:03:15,670 --> 00:03:12,560
roman

79
00:03:16,949 --> 00:03:15,680
well she was born curious she was a

80
00:03:19,589 --> 00:03:16,959
scientist a doctor

81
00:03:22,470 --> 00:03:19,599
of astronomy she was the first female

82
00:03:24,869 --> 00:03:22,480
professor at the university of chicago

83
00:03:26,390 --> 00:03:24,879
she was nasa's first chief of astronomy

84
00:03:27,910 --> 00:03:26,400
and first women to hold

85
00:03:29,509 --> 00:03:27,920
first woman to hold an executive

86
00:03:31,910 --> 00:03:29,519
position she won

87
00:03:34,390 --> 00:03:31,920
numerous awards which will which we'll

88
00:03:37,110 --> 00:03:34,400

take a look at in a little while

89
00:03:38,229 --> 00:03:37,120
she spent her lifetime as a champion of

90
00:03:41,670 --> 00:03:38,239
education

91
00:03:43,270 --> 00:03:41,680
stem and women in the sciences

92
00:03:45,350 --> 00:03:43,280
she was the mother of the hubble space

93
00:03:47,030 --> 00:03:45,360
telescope and now

94
00:03:48,869 --> 00:03:47,040
she has the next nasa's great

95
00:03:52,470 --> 00:03:48,879
observatory wfirst

96
00:03:55,670 --> 00:03:52,480
named after her so

97
00:03:58,229 --> 00:03:55,680
she was born curious um

98
00:03:59,670 --> 00:03:58,239
at a very early age her mother took her

99
00:04:03,670 --> 00:03:59,680
on nature walks

100
00:04:06,949 --> 00:04:03,680
stargazing at starting at age five

101
00:04:08,309 --> 00:04:06,959
her father came up with these games

102
00:04:10,630 --> 00:04:08,319
that she could play and she had a lot of

103
00:04:12,309 --> 00:04:10,640
fun doing it where she would

104
00:04:14,070 --> 00:04:12,319
where he would ask her questions and she

105
00:04:17,270 --> 00:04:14,080
would do mental arithmetic in her

106
00:04:18,870 --> 00:04:17,280
head this was at aj she started an

107
00:04:21,270 --> 00:04:18,880
astronomy club

108
00:04:22,790 --> 00:04:21,280
at age 10 and they looked at this book

109
00:04:24,950 --> 00:04:22,800
seeing stars

110
00:04:27,030 --> 00:04:24,960
to learn all the constellations and of

111
00:04:30,870 --> 00:04:27,040
course she decided to be an astronomer

112
00:04:35,030 --> 00:04:30,880
at age 12. many many of us astronomers

113
00:04:39,749 --> 00:04:37,990

okay so there were other dimensions to

114
00:04:42,070 --> 00:04:39,759
her childhood

115
00:04:43,030 --> 00:04:42,080
due to her father's job the family moved

116
00:04:45,749 --> 00:04:43,040
frequently

117
00:04:48,150 --> 00:04:45,759
five states by three years old eight

118
00:04:50,629 --> 00:04:48,160
schools prior to high school

119
00:04:51,830 --> 00:04:50,639
and every time she had to go to a new

120
00:04:54,870 --> 00:04:51,840
school she had

121
00:04:57,350 --> 00:04:54,880
to study extra to learn the curriculum

122
00:04:57,909 --> 00:04:57,360
because the curricula were different and

123
00:04:59,590 --> 00:04:57,919
i was

124
00:05:01,830 --> 00:04:59,600
talking to her a few years ago about

125
00:05:02,629 --> 00:05:01,840
this and i asked her you know you were

126
00:05:05,590 --> 00:05:02,639
the new kid

127
00:05:06,230 --> 00:05:05,600
in class all the time you're permanently

128
00:05:10,870 --> 00:05:06,240
the new kid

129
00:05:13,990 --> 00:05:10,880
this frustrate you

130
00:05:17,510 --> 00:05:14,000
did all the extra work make you sad

131
00:05:19,590 --> 00:05:17,520
she said no i just got on with it

132
00:05:21,189 --> 00:05:19,600
she did say this what bothered me the

133
00:05:22,870 --> 00:05:21,199
most is that i found it difficult to

134
00:05:24,390 --> 00:05:22,880
make close friends

135
00:05:25,990 --> 00:05:24,400
although i probably would have been an

136
00:05:29,189 --> 00:05:26,000
introverted bookworm

137
00:05:30,710 --> 00:05:29,199
the impermanence did not help also

138
00:05:32,629 --> 00:05:30,720

from a very early age she was

139
00:05:34,469 --> 00:05:32,639
discouraged

140
00:05:35,749 --> 00:05:34,479
to go into a career in science because

141
00:05:37,270 --> 00:05:35,759
she was a woman

142
00:05:38,950 --> 00:05:37,280
her parents were supportive but

143
00:05:41,590 --> 00:05:38,960
concerned anyway

144
00:05:42,390 --> 00:05:41,600
all these experiences that she had as a

145
00:05:44,550 --> 00:05:42,400
child

146
00:05:46,070 --> 00:05:44,560
made her flexible determined stubborn

147
00:05:47,670 --> 00:05:46,080
and open to new things

148
00:05:49,270 --> 00:05:47,680
all of which you will see that she

149
00:05:52,870 --> 00:05:49,280
needed throughout her life

150
00:05:54,230 --> 00:05:52,880
and career nancy grace roman went to

151
00:05:56,710 --> 00:05:54,240
swarthmore college

152
00:05:57,990 --> 00:05:56,720
got a ba in astronomy she credited

153
00:06:00,790 --> 00:05:58,000
swarthmore for

154
00:06:01,350 --> 00:06:00,800
uh her interesting life she blossomed

155
00:06:04,150 --> 00:06:01,360
there

156
00:06:04,550 --> 00:06:04,160
she blossomed in terms of her social

157
00:06:07,029 --> 00:06:04,560
life

158
00:06:07,670 --> 00:06:07,039
her openness to new interests and new

159
00:06:10,710 --> 00:06:07,680
things

160
00:06:13,510 --> 00:06:10,720
and to social issues then after

161
00:06:14,790 --> 00:06:13,520
college she went to the university of uh

162
00:06:18,390 --> 00:06:14,800
chicago

163
00:06:18,870 --> 00:06:18,400

and got her phd at that time she wrote

164
00:06:20,870 --> 00:06:18,880
many

165
00:06:21,990 --> 00:06:20,880
excellent astronomy papers fundamental

166
00:06:25,029 --> 00:06:22,000
papers

167
00:06:25,909 --> 00:06:25,039
but she wrote a landmark paper in 1950

168
00:06:28,629 --> 00:06:25,919
which

169
00:06:30,629 --> 00:06:28,639
actually was on the list of 100 most

170
00:06:32,790 --> 00:06:30,639
important astronomy papers

171
00:06:35,189 --> 00:06:32,800
in the 100 years of the astrophysical

172
00:06:36,710 --> 00:06:35,199
journal which is the astrophysical

173
00:06:38,629 --> 00:06:36,720
journal was the main

174
00:06:41,189 --> 00:06:38,639
is the main astronomical journal

175
00:06:44,309 --> 00:06:41,199
professional journal for astronomers

176
00:06:46,710 --> 00:06:44,319
after her phd she remained at yerkes she

177
00:06:50,390 --> 00:06:46,720
was an instructor researcher and then an

178
00:06:57,830 --> 00:06:54,469
during these times she continued to grow

179
00:07:00,790 --> 00:06:57,840
she said that her foundation her science

180
00:07:02,469 --> 00:07:00,800
education was excellent at yerkes when

181
00:07:04,790 --> 00:07:02,479
she was in grad school

182
00:07:06,469 --> 00:07:04,800
but quote it was clear that they the

183
00:07:08,309 --> 00:07:06,479
astronomy department did not want to

184
00:07:11,589 --> 00:07:08,319
educate women

185
00:07:15,589 --> 00:07:11,599
so she had hurdles to overcome always

186
00:07:16,550 --> 00:07:15,599
hurdles she was ignored by her thesis

187
00:07:18,230 --> 00:07:16,560
advisor

188
00:07:20,870 --> 00:07:18,240

while she was writing her thesis she was

189
00:07:24,150 --> 00:07:20,880
ignored for six months

190
00:07:26,710 --> 00:07:24,160
and i was talking to her about this um

191
00:07:27,430 --> 00:07:26,720
again at the you know a few years ago

192
00:07:30,790 --> 00:07:27,440
and

193
00:07:32,390 --> 00:07:30,800
devastated me

194
00:07:34,469 --> 00:07:32,400
i would have been disillusioned and i

195
00:07:36,469 --> 00:07:34,479
probably would have quit i mean i don't

196
00:07:37,430 --> 00:07:36,479
know how i could recover from my thesis

197
00:07:39,270 --> 00:07:37,440
advisor not

198
00:07:40,629 --> 00:07:39,280
not only not helping me but not talking

199
00:07:43,430 --> 00:07:40,639
to me

200
00:07:44,150 --> 00:07:43,440
and she said no i didn't know why it

201
00:07:46,390 --> 00:07:44,160
happened

202
00:07:48,309 --> 00:07:46,400
but i just got on with it and she did

203
00:07:50,710 --> 00:07:48,319
she talked to other professors

204
00:07:52,150 --> 00:07:50,720
she got help from visiting astronomers

205
00:07:54,550 --> 00:07:52,160
she she

206
00:07:57,430 --> 00:07:54,560
figured out how to continue her thesis

207
00:08:01,909 --> 00:07:57,440
work and she did she graduated

208
00:08:03,430 --> 00:08:01,919
she graduated in time with her phd

209
00:08:05,430 --> 00:08:03,440
then afterwards she was working at

210
00:08:07,270 --> 00:08:05,440
yerkes she was

211
00:08:09,909 --> 00:08:07,280
curious about why she was getting paid

212
00:08:12,309 --> 00:08:09,919
less than some of the techs

213
00:08:13,029 --> 00:08:12,319

who had bachelor's degrees and far less

214
00:08:16,230 --> 00:08:13,039
experience

215
00:08:19,510 --> 00:08:16,240
than her and she went to her her um

216
00:08:21,430 --> 00:08:19,520
department chair asked about it and

217
00:08:22,710 --> 00:08:21,440
another professor uh super minion

218
00:08:25,990 --> 00:08:22,720
chandrasekhar who

219
00:08:28,869 --> 00:08:26,000
was a nobel prize winner in 1983 and

220
00:08:29,830 --> 00:08:28,879
just a wonderful wonderful astronomer

221
00:08:32,149 --> 00:08:29,840
but

222
00:08:32,949 --> 00:08:32,159
he said and she says he said this

223
00:08:34,949 --> 00:08:32,959
innocently

224
00:08:37,430 --> 00:08:34,959
we don't discriminate against women we

225
00:08:39,509 --> 00:08:37,440
can get them for less

226
00:08:42,310 --> 00:08:39,519
anyway this made her resilient

227
00:08:47,110 --> 00:08:42,320
self-reliant creative dedicated

228
00:08:47,120 --> 00:08:52,790
so um oops sorry about that

229
00:08:52,800 --> 00:09:01,030
oh sorry about that

230
00:09:07,269 --> 00:09:05,110
okay so she so uh after

231
00:09:09,350 --> 00:09:07,279
after yerkes observatory she went to the

232
00:09:12,310 --> 00:09:09,360
naval research lab

233
00:09:13,110 --> 00:09:12,320
during that time nasa emerged in 1958

234
00:09:15,350 --> 00:09:13,120
and she was

235
00:09:16,710 --> 00:09:15,360
asked by a colleague do you know anyone

236
00:09:18,949 --> 00:09:16,720
who may want to set up

237
00:09:20,150 --> 00:09:18,959
an astronomy space astronomy program at

238
00:09:23,590 --> 00:09:20,160

nasa

239
00:09:23,990 --> 00:09:23,600
and um and she did and she she became

240
00:09:26,870 --> 00:09:24,000
head

241
00:09:28,870 --> 00:09:26,880
of observational astronomy in 1959

242
00:09:31,350 --> 00:09:28,880
primarily uv and optical

243
00:09:31,910 --> 00:09:31,360
and then in 1960 she was the first

244
00:09:35,269 --> 00:09:31,920
formal

245
00:09:40,070 --> 00:09:35,279
nasa chief of astronomy and uh she

246
00:09:45,430 --> 00:09:41,910
she spearheaded and was the driving

247
00:09:47,190 --> 00:09:45,440
force behind nasa space astronomy

248
00:09:49,350 --> 00:09:47,200
these are some as as you can see down

249
00:09:52,310 --> 00:09:49,360
here i've listed some of the many

250
00:09:55,350 --> 00:09:52,320
many programs that she was responsible

251
00:09:59,030 --> 00:09:57,430
and i'll talk a little bit more about

252
00:10:02,069 --> 00:09:59,040
those

253
00:10:05,910 --> 00:10:04,150
okay so how did how did she succeed how

254
00:10:08,710 --> 00:10:05,920
did she get on with it

255
00:10:10,069 --> 00:10:08,720
well she availed herself as experts in

256
00:10:12,150 --> 00:10:10,079
every astronomy and engineering

257
00:10:15,030 --> 00:10:12,160
discipline she went to them she traveled

258
00:10:16,069 --> 00:10:15,040
all over to talk to the uh astronomers

259
00:10:17,910 --> 00:10:16,079
and asked them

260
00:10:19,190 --> 00:10:17,920
you know what is it that you want to

261
00:10:21,269 --> 00:10:19,200
learn right

262
00:10:22,790 --> 00:10:21,279
what what tools can we make for you to

263
00:10:24,230 --> 00:10:22,800

learn those things

264
00:10:26,150 --> 00:10:24,240
she became the bridge between

265
00:10:28,150 --> 00:10:26,160
engineering engineers

266
00:10:29,750 --> 00:10:28,160
and scientists because they approach

267
00:10:33,030 --> 00:10:29,760
problems differently

268
00:10:35,670 --> 00:10:33,040
she sold space astronomy to politicians

269
00:10:37,990 --> 00:10:35,680
astronomers the government industry and

270
00:10:39,990 --> 00:10:38,000
the public

271
00:10:41,430 --> 00:10:40,000
here are some of her accomplishments i

272
00:10:42,550 --> 00:10:41,440
don't have enough time to go through

273
00:10:45,590 --> 00:10:42,560
this but these are

274
00:10:47,670 --> 00:10:45,600
these are uh you know the first orbiting

275
00:10:51,990 --> 00:10:47,680
astronomical observatories

276
00:10:55,030 --> 00:10:52,000
and uh this top is the orbiting oops boy

277
00:10:56,150 --> 00:10:55,040
uh this this is the orbiting solar

278
00:10:58,389 --> 00:10:56,160
observatory

279
00:11:00,550 --> 00:10:58,399
which was a series of observatories that

280
00:11:02,870 --> 00:11:00,560
looked at the sun in uv

281
00:11:03,750 --> 00:11:02,880
x-ray and gamma ray they also did you

282
00:11:06,790 --> 00:11:03,760
know detected

283
00:11:09,269 --> 00:11:06,800
cosmic gamma rays

284
00:11:12,069 --> 00:11:09,279
the two uh orbiting astronomical

285
00:11:15,190 --> 00:11:12,079
observatories oa2 and three

286
00:11:17,990 --> 00:11:15,200
were extremely productive science

287
00:11:18,949 --> 00:11:18,000
uh in their each of their ways

288
00:11:21,670 --> 00:11:18,959

ultraviolet

289
00:11:22,790 --> 00:11:21,680
and uh x-ray observations and then

290
00:11:25,590 --> 00:11:22,800
there's the international

291
00:11:28,069 --> 00:11:25,600
ultraviolet explorer which whose

292
00:11:31,110 --> 00:11:28,079
three-year mission lasted 18 years

293
00:11:32,069 --> 00:11:31,120
and had a major impact on astronomy and

294
00:11:35,110 --> 00:11:32,079
there are so many

295
00:11:38,310 --> 00:11:35,120
others that you can read about then

296
00:11:42,550 --> 00:11:38,320
there was the large space telescope

297
00:11:45,110 --> 00:11:42,560
and the large space telescope uh

298
00:11:47,750 --> 00:11:45,120
was start astronomers started to talk

299
00:11:51,269 --> 00:11:47,760
about a large space telescope

300
00:11:53,190 --> 00:11:51,279
and it was in 1965 that

301
00:11:55,350 --> 00:11:53,200
that nancy grace roman who again was the

302
00:11:56,790 --> 00:11:55,360
chief of astronomy at nasa said

303
00:11:58,550 --> 00:11:56,800
after all we were never going to get

304
00:11:59,670 --> 00:11:58,560
anywhere if we didn't get started

305
00:12:02,389 --> 00:11:59,680
somewhere

306
00:12:02,790 --> 00:12:02,399
and what i have here up here in this

307
00:12:07,190 --> 00:12:02,800
little

308
00:12:09,670 --> 00:12:07,200
cartoon is that the initial ideas for

309
00:12:12,550 --> 00:12:09,680
for the hubble space telescope large

310
00:12:15,590 --> 00:12:12,560
space telescope in space was to have

311
00:12:18,150 --> 00:12:15,600
an astronaut a man a human

312
00:12:18,710 --> 00:12:18,160
operating the thing and you know nancy

313
00:12:20,310 --> 00:12:18,720

grace

314
00:12:22,389 --> 00:12:20,320
roman said to herself well we're trying

315
00:12:24,949 --> 00:12:22,399
to get away from an atmosphere

316
00:12:26,790 --> 00:12:24,959
uh so we don't want to have an

317
00:12:29,829 --> 00:12:26,800
atmosphere anywhere near or

318
00:12:32,710 --> 00:12:29,839
in the telescope anyway

319
00:12:33,750 --> 00:12:32,720
um she was a tireless advocate for this

320
00:12:36,470 --> 00:12:33,760
large telescope

321
00:12:38,870 --> 00:12:36,480
again met with astronomers politicians

322
00:12:41,910 --> 00:12:38,880
wrote congressional testimony

323
00:12:42,870 --> 00:12:41,920
you know did all the behind the scenes

324
00:12:47,750 --> 00:12:42,880
work

325
00:12:51,350 --> 00:12:47,760
group headed by lyman spitzer

326
00:12:56,389 --> 00:12:53,350
who is considered the father of the

327
00:12:58,949 --> 00:12:56,399
hubble space telescope

328
00:13:00,150 --> 00:12:58,959
she did everything she could to promote

329
00:13:01,829 --> 00:13:00,160
the idea of

330
00:13:03,269 --> 00:13:01,839
uh the space telescope and its

331
00:13:05,350 --> 00:13:03,279
importance

332
00:13:06,870 --> 00:13:05,360
um as you know uh the hubble was

333
00:13:09,670 --> 00:13:06,880
launched in 1990

334
00:13:10,790 --> 00:13:09,680
and it's still performing cutting edge

335
00:13:15,990 --> 00:13:10,800
science 30

336
00:13:20,550 --> 00:13:18,790
bridenstine said of her it is because of

337
00:13:22,790 --> 00:13:20,560
nancy grace roman's leadership

338
00:13:24,710 --> 00:13:22,800

and vision that nasa became a pioneer in

339
00:13:26,870 --> 00:13:24,720
astrophysics and launched hubble

340
00:13:28,790 --> 00:13:26,880
the world's most powerful and productive

341
00:13:32,470 --> 00:13:28,800
space telescope

342
00:13:34,230 --> 00:13:32,480
astronomy is not much different than

343
00:13:36,389 --> 00:13:34,240
galileo's telescope

344
00:13:37,670 --> 00:13:36,399
and that wasn't said by bridenstine it

345
00:13:40,870 --> 00:13:37,680
was said by someone

346
00:13:44,710 --> 00:13:43,110
all right let's let's get to awards and

347
00:13:45,670 --> 00:13:44,720
honors well there's a whole list of them

348
00:13:52,870 --> 00:13:45,680
here

349
00:13:56,470 --> 00:13:52,880
uh her her favorite was the

350
00:13:57,670 --> 00:13:56,480
her favorite two one is the 1962 federal

351
00:14:00,230 --> 00:13:57,680
women's award

352
00:14:01,030 --> 00:14:00,240
and you can see her here accepting the

353
00:14:03,990 --> 00:14:01,040
award

354
00:14:05,350 --> 00:14:04,000
with her five other colleagues who

355
00:14:08,550 --> 00:14:05,360
received the word also

356
00:14:11,670 --> 00:14:08,560
and they're with john f kennedy

357
00:14:12,870 --> 00:14:11,680
then her that her other very favorite

358
00:14:16,470 --> 00:14:12,880
and most fun award

359
00:14:18,389 --> 00:14:16,480
is that she is a lego

360
00:14:19,750 --> 00:14:18,399
and i can i don't have to go through

361
00:14:22,230 --> 00:14:19,760
each of these pictures you can see in

362
00:14:24,230 --> 00:14:22,240
her face

363
00:14:25,829 --> 00:14:24,240

she got such a great kick out of this

364
00:14:28,870 --> 00:14:25,839
she loved it

365
00:14:30,310 --> 00:14:28,880
um anyway you see her here signing the

366
00:14:32,230 --> 00:14:30,320
lego sets and

367
00:14:33,350 --> 00:14:32,240
and this picture is astonishing she's

368
00:14:36,150 --> 00:14:33,360
with you know

369
00:14:37,590 --> 00:14:36,160
margaret hamilton uh both of them

370
00:14:42,870 --> 00:14:37,600
signing their legos

371
00:14:48,389 --> 00:14:45,990
nancy grace roman was an educator she

372
00:14:50,870 --> 00:14:48,399
she taught throughout her life even up

373
00:14:53,750 --> 00:14:50,880
until the year that she passed away

374
00:14:54,389 --> 00:14:53,760
uh she was an educator of all ages here

375
00:14:57,430 --> 00:14:54,399
she is

376
00:14:58,150 --> 00:14:57,440
uh with some students at a toshiba

377
00:15:04,389 --> 00:14:58,160
explorer

378
00:15:05,430 --> 00:15:04,399
nancy and i both worked as as expert

379
00:15:09,030 --> 00:15:05,440
judges on uh

380
00:15:12,550 --> 00:15:09,040
annually for this for this award

381
00:15:13,910 --> 00:15:12,560
she educated uh children young adults

382
00:15:16,389 --> 00:15:13,920
and old adults

383
00:15:18,069 --> 00:15:16,399
as you can see here the old adults here

384
00:15:21,590 --> 00:15:18,079
are the hubble space telescope team

385
00:15:25,750 --> 00:15:21,600
talking to nancy in 2014

386
00:15:29,350 --> 00:15:25,760
and she also

387
00:15:31,350 --> 00:15:29,360
at 2017 went to the march for science

388
00:15:34,230 --> 00:15:31,360

and that this is great she's on the

389
00:15:37,670 --> 00:15:34,240
stage she's waving to her fans

390
00:15:39,829 --> 00:15:37,680
and uh she had written me an email

391
00:15:41,509 --> 00:15:39,839
um which i have part of it here but i

392
00:15:43,670 --> 00:15:41,519
won't read it to you but anyway she was

393
00:15:46,389 --> 00:15:43,680
so thrilled and so excited

394
00:15:46,949 --> 00:15:46,399
to have gone to the march for science

395
00:15:48,629 --> 00:15:46,959
and then

396
00:15:50,629 --> 00:15:48,639
to have been invited by the space

397
00:15:52,949 --> 00:15:50,639
telescope science institute

398
00:15:53,990 --> 00:15:52,959
to attend a three-day conference which

399
00:15:57,990 --> 00:15:54,000
was mostly in her

400
00:16:01,110 --> 00:15:58,000
honor and um she was just

401
00:16:04,470 --> 00:16:01,120
very happy after that those several

402
00:16:08,230 --> 00:16:04,480
days of activities so

403
00:16:09,670 --> 00:16:08,240
that's it um nancy grace roman

404
00:16:11,430 --> 00:16:09,680
is the mother of the hubble space

405
00:16:14,710 --> 00:16:11,440
telescope and now

406
00:16:16,230 --> 00:16:14,720
the the new telescope to be launched by

407
00:16:18,550 --> 00:16:16,240
nasa

408
00:16:20,710 --> 00:16:18,560
to pay tribute to a singular explorer an

409
00:16:23,269 --> 00:16:20,720
inspiration to generations of scientists

410
00:16:25,430 --> 00:16:23,279
and engineers a relentless ally of

411
00:16:26,790 --> 00:16:25,440
astrophysics at nasa a teacher and the

412
00:16:28,629 --> 00:16:26,800
mother of the hubble

413
00:16:30,310 --> 00:16:28,639

thank you nancy grace for forging the

414
00:16:32,870 --> 00:16:30,320
path god speed

415
00:16:34,870 --> 00:16:32,880
and then she says she's very well known

416
00:16:35,509 --> 00:16:34,880
for saying i'm glad i ignored the many

417
00:16:37,110 --> 00:16:35,519
people

418
00:16:38,629 --> 00:16:37,120
who told me that i could not be an

419
00:16:40,069 --> 00:16:38,639
astronomer

420
00:16:45,189 --> 00:16:40,079
and that's it thank you very much for

421
00:16:49,990 --> 00:16:48,389
thank you so much all right our next

422
00:16:52,870 --> 00:16:50,000
speaker will be dr julie

423
00:16:54,710 --> 00:16:52,880
mcenery to tell us about the telescope

424
00:17:00,230 --> 00:16:54,720
that is named for nancy grace roman

425
00:17:03,990 --> 00:17:02,870
thank you um it gives me an enormous

426
00:17:06,309 --> 00:17:04,000
amount of pride to be

427
00:17:07,110 --> 00:17:06,319
associated with uh with a mission that's

428
00:17:09,990 --> 00:17:07,120
named after

429
00:17:11,029 --> 00:17:10,000
nancy grace roman the nancy grace roman

430
00:17:13,990 --> 00:17:11,039
space telescope

431
00:17:15,750 --> 00:17:14,000
is uh the next nasa astrophysics

432
00:17:17,429 --> 00:17:15,760
flagship mission to follow the james

433
00:17:19,669 --> 00:17:17,439
webb space telescope

434
00:17:21,270 --> 00:17:19,679
it was the top-ranked large mission in

435
00:17:24,549 --> 00:17:21,280
the 2010

436
00:17:28,150 --> 00:17:24,559
decadal uh decadal survey and

437
00:17:31,029 --> 00:17:28,160
the one of the singular features of the

438
00:17:32,150 --> 00:17:31,039

nazi grace roman space telescope is that

439
00:17:34,470 --> 00:17:32,160
we have a

440
00:17:36,070 --> 00:17:34,480
primary mirror that is around the same

441
00:17:38,789 --> 00:17:36,080
size as hovels

442
00:17:39,830 --> 00:17:38,799
and that means that we have a similar

443
00:17:42,630 --> 00:17:39,840
sensitivity

444
00:17:43,909 --> 00:17:42,640
and a similar angular resolution or a

445
00:17:48,310 --> 00:17:43,919
sharpness of

446
00:17:51,990 --> 00:17:50,150
but what makes us unique is that we've

447
00:17:52,870 --> 00:17:52,000
got a field of view a factor of 100

448
00:17:55,190 --> 00:17:52,880
larger

449
00:17:56,549 --> 00:17:55,200
so this is illustrated here in this

450
00:17:59,669 --> 00:17:56,559
image of the eagle

451
00:18:03,350 --> 00:17:59,679
nebula and in the center you can see

452
00:18:06,470 --> 00:18:03,360
the famous hubble pillars of creation

453
00:18:09,430 --> 00:18:06,480
image but this observatory

454
00:18:10,070 --> 00:18:09,440
is uh it's not just that it's a hundred

455
00:18:12,950 --> 00:18:10,080
times

456
00:18:14,470 --> 00:18:12,960
uh the field of view of uh of hubble

457
00:18:17,510 --> 00:18:14,480
we're designed to be

458
00:18:21,190 --> 00:18:17,520
um to be a survey instrument so uh

459
00:18:22,150 --> 00:18:21,200
for example if we look at a large survey

460
00:18:25,669 --> 00:18:22,160
that hubble did

461
00:18:27,669 --> 00:18:25,679
of the andromeda galaxy over 400

462
00:18:30,870 --> 00:18:27,679
individual pointings to make up

463
00:18:32,390 --> 00:18:30,880

the fat survey could be completed in two

464
00:18:35,909 --> 00:18:32,400
in just two pointings

465
00:18:40,549 --> 00:18:38,710
but the increase in speed of this survey

466
00:18:43,990 --> 00:18:40,559
is much more than a hundred

467
00:18:46,549 --> 00:18:44,000
because a roman has more efficient

468
00:18:48,150 --> 00:18:46,559
slew and settle in other words it takes

469
00:18:48,549 --> 00:18:48,160
less time to go from one place to the

470
00:18:49,909 --> 00:18:48,559
other

471
00:18:52,150 --> 00:18:49,919
and stop and be ready for the next

472
00:18:53,990 --> 00:18:52,160
observation we don't pass through the

473
00:18:56,630 --> 00:18:54,000
south atlantic anomaly we don't have

474
00:18:58,630 --> 00:18:56,640
interruptions in observations because

475
00:19:01,909 --> 00:18:58,640
the earth gets in the field of view

476
00:19:03,750 --> 00:19:01,919
so in this particular case the increase

477
00:19:06,390 --> 00:19:03,760
in speed to do this survey isn't a

478
00:19:09,909 --> 00:19:06,400
factor of 100 it isn't a factor of 200

479
00:19:11,270 --> 00:19:09,919
it's a factor of over a thousand so with

480
00:19:14,630 --> 00:19:11,280
an observatory like

481
00:19:17,430 --> 00:19:14,640
um like roman um

482
00:19:18,549 --> 00:19:17,440
we can view the universe in an entirely

483
00:19:21,190 --> 00:19:18,559
new way

484
00:19:22,789 --> 00:19:21,200
uh we can do surveys of things where we

485
00:19:24,310 --> 00:19:22,799
can wait for things to happen because

486
00:19:25,430 --> 00:19:24,320
we're looking over a large enough field

487
00:19:28,310 --> 00:19:25,440
of view to find

488
00:19:29,909 --> 00:19:28,320

things that that go off or we can survey

489
00:19:33,510 --> 00:19:29,919
large regions of the sky

490
00:19:36,150 --> 00:19:33,520
to map out distributions

491
00:19:36,950 --> 00:19:36,160
so with this large amount of larger

492
00:19:38,630 --> 00:19:36,960
field of view

493
00:19:40,310 --> 00:19:38,640
more efficient observations we're

494
00:19:41,110 --> 00:19:40,320
getting more information which of course

495
00:19:43,270 --> 00:19:41,120
translates

496
00:19:44,150 --> 00:19:43,280
into much much more data so one of the

497
00:19:47,110 --> 00:19:44,160
other features

498
00:19:48,070 --> 00:19:47,120
of uh of the roman observatory is it's

499
00:19:50,070 --> 00:19:48,080
going to change

500
00:19:52,230 --> 00:19:50,080
how we're how we interact with our data

501
00:19:53,990 --> 00:19:52,240
sets that the amount of data

502
00:19:55,830 --> 00:19:54,000
is much much larger so the typical

503
00:19:58,710 --> 00:19:55,840
astronomer is not going to be

504
00:20:00,310 --> 00:19:58,720
downloading data to their um uh to their

505
00:20:01,510 --> 00:20:00,320
home machine and doing analysis and

506
00:20:03,270 --> 00:20:01,520
instead we will have

507
00:20:05,510 --> 00:20:03,280
we're introducing ways where people can

508
00:20:10,230 --> 00:20:05,520
work remotely um on the

509
00:20:16,310 --> 00:20:13,510
another way in which uh roman

510
00:20:17,909 --> 00:20:16,320
is uh is unique is that one of our

511
00:20:20,950 --> 00:20:17,919
science drivers

512
00:20:23,350 --> 00:20:20,960
is uh to study cosmology to study the

513
00:20:26,070 --> 00:20:23,360

structure and evolution of the universe

514
00:20:28,310 --> 00:20:26,080
and we do this with several surveys and

515
00:20:32,149 --> 00:20:28,320
as i said we're designed to do surveys

516
00:20:35,909 --> 00:20:32,159
a large survey away from the

517
00:20:38,470 --> 00:20:35,919
galactic plane is designed to

518
00:20:39,110 --> 00:20:38,480
detect hundreds of millions of galaxies

519
00:20:41,110 --> 00:20:39,120
and measure

520
00:20:43,029 --> 00:20:41,120
precisely the position and distance to

521
00:20:45,510 --> 00:20:43,039
each one

522
00:20:47,669 --> 00:20:45,520
a fraction of these we can also very

523
00:20:52,070 --> 00:20:47,679
precisely measure

524
00:20:53,909 --> 00:20:52,080
the shape of those galaxies and look for

525
00:20:56,950 --> 00:20:53,919
deviations in the measured shape of the

526
00:21:00,710 --> 00:20:56,960
galaxy produced by dark matter between

527
00:21:03,750 --> 00:21:00,720
us and those galaxies

528
00:21:06,789 --> 00:21:03,760
we also plan to have another survey

529
00:21:08,070 --> 00:21:06,799
that points again away from the from the

530
00:21:10,710 --> 00:21:08,080
milky way galaxy

531
00:21:11,590 --> 00:21:10,720
that goes back to the same spot on the

532
00:21:14,470 --> 00:21:11,600
sky

533
00:21:16,070 --> 00:21:14,480
every five days for years and this

534
00:21:17,669 --> 00:21:16,080
survey will monitor hundreds of

535
00:21:19,990 --> 00:21:17,679
thousands of galaxies

536
00:21:21,029 --> 00:21:20,000
and find every supernova that occurs in

537
00:21:22,630 --> 00:21:21,039
that region

538
00:21:24,230 --> 00:21:22,640

we'll detect tens of thousands of

539
00:21:25,190 --> 00:21:24,240
supernovas and we'll use those as a

540
00:21:27,830 --> 00:21:25,200
standard candle

541
00:21:30,630 --> 00:21:27,840
as yet another way to explore uh the

542
00:21:33,110 --> 00:21:30,640
structure and evolution of the universe

543
00:21:34,710 --> 00:21:33,120
and the next speakers will describe this

544
00:21:35,750 --> 00:21:34,720
in more detail but the point that i want

545
00:21:38,630 --> 00:21:35,760
to make here

546
00:21:40,230 --> 00:21:38,640
is that measuring galaxy shapes is hard

547
00:21:42,310 --> 00:21:40,240
that we need to understand our point

548
00:21:44,310 --> 00:21:42,320
spread function

549
00:21:46,070 --> 00:21:44,320
to one part in a thousand that's a

550
00:21:47,909 --> 00:21:46,080
factor of a few better than hubble

551
00:21:49,750 --> 00:21:47,919
we need to understand um our flux

552
00:21:52,310 --> 00:21:49,760
measurement our ability to

553
00:21:53,830 --> 00:21:52,320
uh translate how much light we see in

554
00:21:55,669 --> 00:21:53,840
the detector to how much light

555
00:21:57,350 --> 00:21:55,679
actually came from the object to a

556
00:22:00,070 --> 00:21:57,360
factor of 10 better than hubble

557
00:22:02,070 --> 00:22:00,080
so what we're doing is not only making

558
00:22:03,909 --> 00:22:02,080
observations over a larger field of view

559
00:22:06,950 --> 00:22:03,919
but we're making those observations

560
00:22:08,230 --> 00:22:06,960
much much more precisely so that we can

561
00:22:10,070 --> 00:22:08,240
get an understanding of

562
00:22:11,830 --> 00:22:10,080
dark energy dark matter and

563
00:22:15,350 --> 00:22:11,840

understanding of potentially modified

564
00:22:19,990 --> 00:22:18,390
unlike uh hubble uh the nancy grace

565
00:22:23,110 --> 00:22:20,000
roman space telescope

566
00:22:24,070 --> 00:22:23,120
is not uh in orbit around our earth so

567
00:22:26,789 --> 00:22:24,080
what you're seeing

568
00:22:27,350 --> 00:22:26,799
um here is the moon going around the

569
00:22:29,430 --> 00:22:27,360
earth

570
00:22:30,870 --> 00:22:29,440
on the left hand side and on the right

571
00:22:33,110 --> 00:22:30,880
hand side you see

572
00:22:35,350 --> 00:22:33,120
roman in its orbit around the second

573
00:22:38,470 --> 00:22:35,360
lagrange point

574
00:22:41,590 --> 00:22:38,480
this orbit is what enables us to have

575
00:22:42,630 --> 00:22:41,600
a patch on the sky that we can monitor

576
00:22:45,590 --> 00:22:42,640
for supernova

577
00:22:46,230 --> 00:22:45,600
for years at a time uninterrupted it's

578
00:22:49,590 --> 00:22:46,240
also what

579
00:22:56,310 --> 00:22:53,110
to move to the next slide

580
00:22:59,669 --> 00:22:56,320
to monitor um our galactic center

581
00:23:01,510 --> 00:22:59,679
um every 15 minutes for um

582
00:23:04,710 --> 00:23:01,520
for months at a time because the earth

583
00:23:07,990 --> 00:23:07,190
with our observations of the galactic

584
00:23:11,270 --> 00:23:08,000
bulge

585
00:23:13,510 --> 00:23:11,280
we're not focusing here on cosmology

586
00:23:14,470 --> 00:23:13,520
one of the things that we can do here is

587
00:23:17,270 --> 00:23:14,480
to

588
00:23:18,549 --> 00:23:17,280

look for changes in brightness of stars

589
00:23:22,950 --> 00:23:18,559
caused by

590
00:23:26,710 --> 00:23:22,960
uh the gravitational lensing as a star

591
00:23:30,390 --> 00:23:26,720
with a planet moves moves in front

592
00:23:32,630 --> 00:23:30,400
this technique will allow us to measure

593
00:23:33,990 --> 00:23:32,640
ice and giant uh planets similar to the

594
00:23:35,669 --> 00:23:34,000
ones in our solar system

595
00:23:37,350 --> 00:23:35,679
that are unattainable by other surveys

596
00:23:39,590 --> 00:23:37,360
so we'll complete the census

597
00:23:42,230 --> 00:23:39,600
of the mass of exoplanets while

598
00:23:44,230 --> 00:23:42,240
simultaneously be sensitive to planets

599
00:23:47,590 --> 00:23:44,240
down to the mouths of our jupiter's moon

600
00:23:50,710 --> 00:23:50,310
so this has been a very quick uh whirl

601
00:23:52,630 --> 00:23:50,720
through

602
00:23:54,310 --> 00:23:52,640
of the nancy grace roman space telescope

603
00:23:57,029 --> 00:23:54,320
that we've got a large field of view

604
00:23:57,669 --> 00:23:57,039
that we've got uh an orbit that promotes

605
00:24:00,470 --> 00:23:57,679
us

606
00:24:01,909 --> 00:24:00,480
um stability of the observatory so that

607
00:24:03,669 --> 00:24:01,919
we can have an extremely

608
00:24:04,950 --> 00:24:03,679
uh precisely and well understood

609
00:24:07,269 --> 00:24:04,960
observations

610
00:24:09,350 --> 00:24:07,279
and that we can have continuous both

611
00:24:12,630 --> 00:24:09,360
large surveys and

612
00:24:14,870 --> 00:24:12,640
highly temporally resolve surveys

613
00:24:16,230 --> 00:24:14,880

to do unique science and i've

614
00:24:19,430 --> 00:24:16,240
intentionally ended

615
00:24:20,950 --> 00:24:19,440
on exoplanets as uh

616
00:24:22,950 --> 00:24:20,960
as a science case because the next

617
00:24:25,750 --> 00:24:22,960
speaker is going to

618
00:24:26,950 --> 00:24:25,760
focus on the second instrument on roman

619
00:24:29,029 --> 00:24:26,960
uh which is designed

620
00:24:29,990 --> 00:24:29,039
uh to image exoplanets themselves

621
00:24:35,350 --> 00:24:30,000
directly

622
00:24:39,269 --> 00:24:38,549
thank you julie uh so now we'll turn it

623
00:24:41,590 --> 00:24:39,279
over to

624
00:24:51,990 --> 00:24:41,600
jason rhodes to tell us about the

625
00:24:52,000 --> 00:25:02,549
you need to admit jason

626
00:25:10,149 --> 00:25:06,470
yes now i'm unmuted thank you

627
00:25:15,830 --> 00:25:13,510
looks good okay thank you uh yes

628
00:25:16,950 --> 00:25:15,840
julie uh just told you about all the

629
00:25:18,630 --> 00:25:16,960
exciting science

630
00:25:19,830 --> 00:25:18,640
roman is going to do with its wide field

631
00:25:21,269 --> 00:25:19,840
instrument i'm going to tell you about

632
00:25:23,190 --> 00:25:21,279
the second instrument

633
00:25:24,710 --> 00:25:23,200
on roman which is the coronagraph

634
00:25:27,830 --> 00:25:24,720
instrument or cgi

635
00:25:28,470 --> 00:25:27,840
this is a tech demonstration instrument

636
00:25:30,789 --> 00:25:28,480
meant to

637
00:25:32,950 --> 00:25:30,799
prove out a number of technologies that

638
00:25:35,110 --> 00:25:32,960

we think will revolutionize

639
00:25:36,549 --> 00:25:35,120
the field of exoplanet study over the

640
00:25:39,029 --> 00:25:36,559
coming two decades

641
00:25:40,390 --> 00:25:39,039
exoplanets of course are planets outside

642
00:25:42,470 --> 00:25:40,400
of our solar system

643
00:25:45,029 --> 00:25:42,480
and over the past few decades uh we've

644
00:25:46,789 --> 00:25:45,039
discovered about 4 000 exoplanets

645
00:25:49,029 --> 00:25:46,799
in one of the surveys that julie just

646
00:25:49,909 --> 00:25:49,039
described roman itself will discover

647
00:25:53,110 --> 00:25:49,919
another 2

648
00:25:54,149 --> 00:25:53,120
000 exoplanets but of these 6 000 plus

649
00:25:55,990 --> 00:25:54,159
exoplanets

650
00:25:57,909 --> 00:25:56,000
most of them have been detected

651
00:25:59,830 --> 00:25:57,919
indirectly that is we look for

652
00:26:01,830 --> 00:25:59,840
a wobble in the starlight or a blinking

653
00:26:02,470 --> 00:26:01,840
of the starlight and we don't see the

654
00:26:05,430 --> 00:26:02,480
planet

655
00:26:06,230 --> 00:26:05,440
itself a coronagraph is an instrument on

656
00:26:08,070 --> 00:26:06,240
the other hand

657
00:26:09,590 --> 00:26:08,080
that's designed to take pictures of the

658
00:26:12,149 --> 00:26:09,600
planet itself

659
00:26:13,110 --> 00:26:12,159
and in this artist's recreation here i'm

660
00:26:15,510 --> 00:26:13,120
showing you

661
00:26:17,269 --> 00:26:15,520
conceptually how a coronagraph works so

662
00:26:19,750 --> 00:26:17,279
we have this planet

663
00:26:21,190 --> 00:26:19,760

orbiting a star and if we wanted to use

664
00:26:23,750 --> 00:26:21,200
a regular instrument

665
00:26:24,630 --> 00:26:23,760
on a regular telescope to look at this

666
00:26:26,549 --> 00:26:24,640
the star

667
00:26:28,710 --> 00:26:26,559
would over shine the planet so the

668
00:26:30,630 --> 00:26:28,720
planet would be lost in the starlight

669
00:26:31,990 --> 00:26:30,640
so what a coronagraph is it's an

670
00:26:33,590 --> 00:26:32,000
instrument that has what we call an

671
00:26:36,549 --> 00:26:33,600
internal occulter

672
00:26:37,990 --> 00:26:36,559
simply a disc that goes over the star

673
00:26:41,110 --> 00:26:38,000
blocks the starlight

674
00:26:42,950 --> 00:26:41,120
and allows us to see the planet itself

675
00:26:44,390 --> 00:26:42,960
now the reason that this is very very

676
00:26:47,269 --> 00:26:44,400
challenging is because

677
00:26:48,789 --> 00:26:47,279
stars are so much brighter than planets

678
00:26:51,029 --> 00:26:48,799
so what i'm going to show you here

679
00:26:51,990 --> 00:26:51,039
is an analogy so if you imagine a

680
00:26:54,870 --> 00:26:52,000
sun-like star

681
00:26:55,350 --> 00:26:54,880
and think of that as a lighthouse a very

682
00:26:57,269 --> 00:26:55,360
big

683
00:26:59,510 --> 00:26:57,279
very bright planet like a hot exo

684
00:27:01,830 --> 00:26:59,520
jupiter that's so hot it's giving off

685
00:27:02,789 --> 00:27:01,840
its own light would be about a million

686
00:27:05,110 --> 00:27:02,799
times fainter

687
00:27:05,990 --> 00:27:05,120
than that sun-like star this is like

688
00:27:08,950 --> 00:27:06,000

trying to see a

689
00:27:10,870 --> 00:27:08,960
firefly flying around a lighthouse if

690
00:27:13,110 --> 00:27:10,880
you're thousands of miles away

691
00:27:14,149 --> 00:27:13,120
from the firefly in the lighthouse

692
00:27:16,230 --> 00:27:14,159
however nasa's

693
00:27:17,269 --> 00:27:16,240
ultimate goal is to look for an

694
00:27:19,590 --> 00:27:17,279
earth-like planet

695
00:27:20,310 --> 00:27:19,600
in the habitable zone around a sun-like

696
00:27:23,029 --> 00:27:20,320
star

697
00:27:23,669 --> 00:27:23,039
this is a contrast ratio of 10 billion

698
00:27:26,470 --> 00:27:23,679
to one

699
00:27:27,430 --> 00:27:26,480
or ten thousand times uh more

700
00:27:29,909 --> 00:27:27,440
challenging

701
00:27:31,909 --> 00:27:29,919
than this one million contrast ratio

702
00:27:34,070 --> 00:27:31,919
which is what coronagraphs now

703
00:27:35,430 --> 00:27:34,080
on the ground and in space can do this

704
00:27:39,269 --> 00:27:35,440
would be like trying to see

705
00:27:41,110 --> 00:27:39,279
a single celled bioluminescent organism

706
00:27:42,710 --> 00:27:41,120
near a lighthouse if you were thousands

707
00:27:44,710 --> 00:27:42,720
of miles away

708
00:27:45,990 --> 00:27:44,720
now roman will not get us all the way

709
00:27:48,149 --> 00:27:46,000
there roman

710
00:27:49,990 --> 00:27:48,159
we anticipate will have a contrast ratio

711
00:27:51,750 --> 00:27:50,000
of about a billion to one

712
00:27:53,430 --> 00:27:51,760
but we're going to do that by proving

713
00:27:55,590 --> 00:27:53,440

out a number of technologies

714
00:27:57,510 --> 00:27:55,600
that we think on a future observatory

715
00:27:59,510 --> 00:27:57,520
perhaps in the 2030s

716
00:28:01,029 --> 00:27:59,520
could get us to this 10 billion to 1

717
00:28:02,389 --> 00:28:01,039
contrast ratio

718
00:28:04,230 --> 00:28:02,399
so the first thing we're going to do

719
00:28:05,590 --> 00:28:04,240
with roman obviously is we're going to

720
00:28:07,909 --> 00:28:05,600
fly it in space

721
00:28:09,430 --> 00:28:07,919
above the effects of the atmosphere

722
00:28:12,230 --> 00:28:09,440
which tend to scatter light

723
00:28:12,789 --> 00:28:12,240
and make it much more difficult to uh

724
00:28:14,630 --> 00:28:12,799
block

725
00:28:15,990 --> 00:28:14,640
the starlight and let the planet light

726
00:28:18,549 --> 00:28:16,000
through and the first

727
00:28:20,389 --> 00:28:18,559
paper to suggest using a space telescope

728
00:28:23,269 --> 00:28:20,399
to directly image exoplanets

729
00:28:23,909 --> 00:28:23,279
was written in 1959 by nancy grace roman

730
00:28:25,830 --> 00:28:23,919
herself

731
00:28:27,909 --> 00:28:25,840
so it's pretty exciting that this

732
00:28:30,230 --> 00:28:27,919
instrument is going on the telescope

733
00:28:32,149 --> 00:28:30,240
named after her as i said before there's

734
00:28:33,590 --> 00:28:32,159
a number of new technologies that we're

735
00:28:35,830 --> 00:28:33,600
going to prove out here

736
00:28:36,789 --> 00:28:35,840
what i'm showing here is just an artist

737
00:28:39,269 --> 00:28:36,799
recreation

738
00:28:40,950 --> 00:28:39,279

of a few pieces of the optical elements

739
00:28:43,590 --> 00:28:40,960
of a coronagraph

740
00:28:43,990 --> 00:28:43,600
the wfirst roman coronagraph and the

741
00:28:46,389 --> 00:28:44,000
yellow

742
00:28:47,190 --> 00:28:46,399
here is the path of light through the

743
00:28:49,110 --> 00:28:47,200
system

744
00:28:50,230 --> 00:28:49,120
if you look up here you'll see that the

745
00:28:52,149 --> 00:28:50,240
light coming in

746
00:28:54,630 --> 00:28:52,159
is imperfect it doesn't form perfect

747
00:28:56,470 --> 00:28:54,640
waves and those imperfect waves

748
00:28:57,990 --> 00:28:56,480
are due to imperfections in the mirror

749
00:29:00,070 --> 00:28:58,000
and the telescope we can never

750
00:29:01,029 --> 00:29:00,080
build a perfect mirror or a perfect

751
00:29:02,950 --> 00:29:01,039
telescope

752
00:29:04,230 --> 00:29:02,960
and because of those imperfections it's

753
00:29:06,950 --> 00:29:04,240
more challenging

754
00:29:07,590 --> 00:29:06,960
to block the light of the star so what

755
00:29:10,950 --> 00:29:07,600
we do

756
00:29:12,950 --> 00:29:10,960
is we have two small deformable mirrors

757
00:29:15,110 --> 00:29:12,960
these are small mirrors about the size

758
00:29:16,470 --> 00:29:15,120
of a quarter but each of them has about

759
00:29:18,549 --> 00:29:16,480
2 000 pistons

760
00:29:20,230 --> 00:29:18,559
on the mirror that allows us to change

761
00:29:22,389 --> 00:29:20,240
the shape of the mirror

762
00:29:23,830 --> 00:29:22,399
and correct those imperfections in the

763
00:29:26,310 --> 00:29:23,840

wavefront

764
00:29:27,669 --> 00:29:26,320
we're also going to use complex

765
00:29:29,590 --> 00:29:27,679
coronagraph masks

766
00:29:31,750 --> 00:29:29,600
not the simple discs that i showed you

767
00:29:32,950 --> 00:29:31,760
before these coronagraph masks are

768
00:29:34,630 --> 00:29:32,960
designed to

769
00:29:36,230 --> 00:29:34,640
send the light from the star to the

770
00:29:38,230 --> 00:29:36,240
outer edges of our field

771
00:29:39,269 --> 00:29:38,240
and then we block it with another

772
00:29:40,789 --> 00:29:39,279
optical element

773
00:29:43,510 --> 00:29:40,799
and the planet light comes in at a

774
00:29:46,630 --> 00:29:43,520
different angle and so that planet light

775
00:29:47,590 --> 00:29:46,640
reaches our uh focal plane and that's

776
00:29:48,870 --> 00:29:47,600
what we detect

777
00:29:51,590 --> 00:29:48,880
but what you're seeing here in this

778
00:29:53,269 --> 00:29:51,600
picture is that not all of the starlight

779
00:29:54,870 --> 00:29:53,279
is blocked and that's what makes

780
00:29:57,909 --> 00:29:54,880
cornography challenging

781
00:29:58,710 --> 00:29:57,919
we need to block uh with roman about a

782
00:30:01,430 --> 00:29:58,720
billion

783
00:30:02,310 --> 00:30:01,440
photons from the star for every one that

784
00:30:04,950 --> 00:30:02,320
we detect

785
00:30:06,549 --> 00:30:04,960
from the planet so we're going to test

786
00:30:09,430 --> 00:30:06,559
out and prove out

787
00:30:10,389 --> 00:30:09,440
five new technologies uh with the roman

788
00:30:12,950 --> 00:30:10,399

coronagraph

789
00:30:15,269 --> 00:30:12,960
the first is ultra precise wavefront

790
00:30:17,990 --> 00:30:15,279
sensing and control it's sensing those

791
00:30:19,510 --> 00:30:18,000
wavefront errors that i talked about uh

792
00:30:20,630 --> 00:30:19,520
and then we're going to correct those

793
00:30:22,149 --> 00:30:20,640
waveform errors

794
00:30:24,310 --> 00:30:22,159
with the first use of these small

795
00:30:26,549 --> 00:30:24,320
deformable mirrors in space

796
00:30:27,350 --> 00:30:26,559
then we'll use high contrast coronagraph

797
00:30:29,510 --> 00:30:27,360
masks

798
00:30:30,870 --> 00:30:29,520
that have a complex structure that's

799
00:30:33,190 --> 00:30:30,880
meant to allow us

800
00:30:35,190 --> 00:30:33,200
to account for diffraction and

801
00:30:36,630 --> 00:30:35,200
reflections inside the telescope and the

802
00:30:39,110 --> 00:30:36,640
instrument itself

803
00:30:40,549 --> 00:30:39,120
will detect the photons with ultra low

804
00:30:43,830 --> 00:30:40,559
noise counting detectors

805
00:30:45,830 --> 00:30:43,840
that can detect single photons at a time

806
00:30:47,750 --> 00:30:45,840
and finally we'll process these images

807
00:30:49,830 --> 00:30:47,760
with new algorithms

808
00:30:51,110 --> 00:30:49,840
meant for these unprecedented contrast

809
00:30:53,830 --> 00:30:51,120
levels and again

810
00:30:55,830 --> 00:30:53,840
this is going to allow us to get to a

811
00:30:58,389 --> 00:30:55,840
billion to one contrast ratio

812
00:30:59,110 --> 00:30:58,399
which is a thousand times better than

813
00:31:01,350 --> 00:30:59,120

existing

814
00:31:02,789 --> 00:31:01,360
uh coronagraphs and i think it's it's a

815
00:31:04,630 --> 00:31:02,799
nice coincidence that

816
00:31:06,310 --> 00:31:04,640
julie described that the wide-field

817
00:31:08,389 --> 00:31:06,320
instrument was a thousand times

818
00:31:09,509 --> 00:31:08,399
uh more capable than the similar

819
00:31:11,830 --> 00:31:09,519
instruments on the hubble

820
00:31:13,430 --> 00:31:11,840
and of course the cgi the coronagraph is

821
00:31:14,870 --> 00:31:13,440
a thousand times more capable than

822
00:31:17,190 --> 00:31:14,880
existing coronagraphs

823
00:31:18,549 --> 00:31:17,200
but the real goal here is to prove out

824
00:31:20,470 --> 00:31:18,559
these technologies

825
00:31:22,470 --> 00:31:20,480
that will allow us to fly a future

826
00:31:23,509 --> 00:31:22,480
mission that could use these same

827
00:31:25,990 --> 00:31:23,519
technologies

828
00:31:30,230 --> 00:31:26,000
to look for potential signs of life on

829
00:31:34,470 --> 00:31:30,240
earth-like planets around sun-like stars

830
00:31:38,710 --> 00:31:38,230
thank you jason all right now that we've

831
00:31:40,630 --> 00:31:38,720
uh

832
00:31:41,990 --> 00:31:40,640
learned a bit more about the telescope

833
00:31:44,389 --> 00:31:42,000
itself we are going to

834
00:31:46,789 --> 00:31:44,399
delve more deeply into the science that

835
00:31:49,190 --> 00:31:46,799
the roman space telescope will do

836
00:31:49,909 --> 00:31:49,200
so our next speaker will be dr adam

837
00:31:54,549 --> 00:31:49,919
reese

838
00:32:03,669 --> 00:31:57,590

okay let's see i need permission

839
00:32:03,679 --> 00:32:16,870
i think jason will have to unshare first

840
00:32:16,880 --> 00:32:23,750
there we go

841
00:32:30,230 --> 00:32:27,110
okay can you uh see my screen okay

842
00:32:32,230 --> 00:32:30,240
yes thank you great uh well

843
00:32:33,909 --> 00:32:32,240
thank you very much for joining me in

844
00:32:35,590 --> 00:32:33,919
this workshop to discuss

845
00:32:37,909 --> 00:32:35,600
uh the capabilities of the roman

846
00:32:40,870 --> 00:32:37,919
telescope i'm gonna follow up on

847
00:32:42,950 --> 00:32:40,880
uh what julie discussed in terms of how

848
00:32:43,590 --> 00:32:42,960
roman will help us learn more about the

849
00:32:45,750 --> 00:32:43,600
physics

850
00:32:47,830 --> 00:32:45,760
of the universe i'm going to tell you

851
00:32:49,509 --> 00:32:47,840
how over the last couple of decades

852
00:32:51,590 --> 00:32:49,519
we've been observing the expansion

853
00:32:52,950 --> 00:32:51,600
history of the universe how it has

854
00:32:55,990 --> 00:32:52,960
pointed to the presence

855
00:32:57,830 --> 00:32:56,000
of dark energy in the universe and how

856
00:32:59,590 --> 00:32:57,840
uh hopefully roman will help us

857
00:33:02,549 --> 00:32:59,600
understand some of the enigmas

858
00:33:04,149 --> 00:33:02,559
uh involved in uh the what we see about

859
00:33:07,669 --> 00:33:04,159
the universe

860
00:33:10,070 --> 00:33:07,679
we see

861
00:33:10,870 --> 00:33:10,080
it expanding around us this is certainly

862
00:33:13,590 --> 00:33:10,880
one of the most

863
00:33:14,710 --> 00:33:13,600

remarkable facts about the universe

864
00:33:17,669 --> 00:33:14,720
distant objects

865
00:33:18,310 --> 00:33:17,679
appear to be moving away from us as uh

866
00:33:20,710 --> 00:33:18,320
told by

867
00:33:21,350 --> 00:33:20,720
their redshifts and the further away

868
00:33:24,310 --> 00:33:21,360
they are

869
00:33:26,310 --> 00:33:24,320
the faster they appear to recede from us

870
00:33:28,710 --> 00:33:26,320
so how do we learn these things about

871
00:33:31,750 --> 00:33:28,720
the universe well we have to measure

872
00:33:34,549 --> 00:33:31,760
distances to some of these galaxies and

873
00:33:35,350 --> 00:33:34,559
their recession as told by their

874
00:33:37,430 --> 00:33:35,360
redshifts

875
00:33:38,710 --> 00:33:37,440
and one of the best ways astronomers

876
00:33:41,190 --> 00:33:38,720
have of doing that

877
00:33:43,430 --> 00:33:41,200
is using a class of exploding star

878
00:33:45,350 --> 00:33:43,440
called a type 1a supernova

879
00:33:47,269 --> 00:33:45,360
this is a star that has attained the

880
00:33:48,870 --> 00:33:47,279
chandrasekhar mass

881
00:33:50,710 --> 00:33:48,880
and you get a runaway thermonuclear

882
00:33:52,310 --> 00:33:50,720
explosion when a star exceeds the

883
00:33:54,389 --> 00:33:52,320
chandrasekhar mass

884
00:33:56,230 --> 00:33:54,399
these kinds of objects can be seen more

885
00:33:57,990 --> 00:33:56,240
than halfway across the universe

886
00:33:59,269 --> 00:33:58,000
and we've been diligently using the

887
00:34:02,230 --> 00:33:59,279
hubble space telescope

888
00:34:03,590 --> 00:34:02,240

for about 20 years to map the expansion

889
00:34:05,830 --> 00:34:03,600
history of the universe

890
00:34:06,789 --> 00:34:05,840
and so once we have measured the

891
00:34:09,829 --> 00:34:06,799
distances

892
00:34:10,950 --> 00:34:09,839
and the redshifts of these hosts of

893
00:34:13,270 --> 00:34:10,960
supernovae

894
00:34:14,790 --> 00:34:13,280
we can make a sort of plot or diagram

895
00:34:16,710 --> 00:34:14,800
like you see on the right

896
00:34:18,310 --> 00:34:16,720
and the linear relationship between

897
00:34:20,790 --> 00:34:18,320
distance and redshift the fact that

898
00:34:21,349 --> 00:34:20,800
something further away is moving faster

899
00:34:23,030 --> 00:34:21,359
from us

900
00:34:24,629 --> 00:34:23,040
is the signature of an expanding

901
00:34:26,869 --> 00:34:24,639
universe we measure

902
00:34:28,230 --> 00:34:26,879
this relationship or slope to determine

903
00:34:30,950 --> 00:34:28,240
exactly how fast

904
00:34:32,550 --> 00:34:30,960
the universe is expanding today a value

905
00:34:35,750 --> 00:34:32,560
known as the hubble constant

906
00:34:36,790 --> 00:34:35,760
and if we look further out further back

907
00:34:38,790 --> 00:34:36,800
in time

908
00:34:40,230 --> 00:34:38,800
we can measure how fast the universe was

909
00:34:42,710 --> 00:34:40,240
expanding in the past

910
00:34:45,109 --> 00:34:42,720
to compare that to today and see how

911
00:34:48,470 --> 00:34:45,119
that rate has changed over time

912
00:34:50,389 --> 00:34:48,480
now of course decades ago we assumed

913
00:34:51,510 --> 00:34:50,399

that the expansion of the universe would

914
00:34:53,829 --> 00:34:51,520
be slowing

915
00:34:55,589 --> 00:34:53,839
because of the attractive gravity of

916
00:34:57,829 --> 00:34:55,599
matter in the universe

917
00:35:00,630 --> 00:34:57,839
however einstein who thought about this

918
00:35:02,710 --> 00:35:00,640
problem even earlier than most of us

919
00:35:05,910 --> 00:35:02,720
realized there was another possibility

920
00:35:08,390 --> 00:35:05,920
that the gravity of empty space itself

921
00:35:09,589 --> 00:35:08,400
uh could be repulsive and could push

922
00:35:11,670 --> 00:35:09,599
back against the

923
00:35:13,030 --> 00:35:11,680
attractive gravity of ordinary stuff in

924
00:35:15,190 --> 00:35:13,040
the universe he called this

925
00:35:16,069 --> 00:35:15,200
property the cosmological constant and

926
00:35:19,270 --> 00:35:16,079
today we would call

927
00:35:21,430 --> 00:35:19,280
this dark energy of course this is not

928
00:35:23,190 --> 00:35:21,440
what we expected to be going on some 20

929
00:35:25,589 --> 00:35:23,200
years ago my colleagues and i

930
00:35:27,750 --> 00:35:25,599
made some of the first measurements of

931
00:35:30,150 --> 00:35:27,760
the expansion history of the universe

932
00:35:31,349 --> 00:35:30,160
comparing the expansion rate today as

933
00:35:33,750 --> 00:35:31,359
you see there in the

934
00:35:35,670 --> 00:35:33,760
red data point two distant points we

935
00:35:37,510 --> 00:35:35,680
thought we would determine whether

936
00:35:39,109 --> 00:35:37,520
the expansion was slowing down a lot

937
00:35:39,750 --> 00:35:39,119
that is we lived in a heavyweight

938
00:35:41,270 --> 00:35:39,760

universe

939
00:35:42,630 --> 00:35:41,280
or only a little that we lived in a

940
00:35:44,710 --> 00:35:42,640
lightweight universe and of course this

941
00:35:46,390 --> 00:35:44,720
was a tremendous surprise

942
00:35:47,750 --> 00:35:46,400
when we made these measurements and

943
00:35:49,910 --> 00:35:47,760
found that in fact

944
00:35:52,390 --> 00:35:49,920
the expansion rate of the universe has

945
00:35:54,390 --> 00:35:52,400
been speeding up over time this was uh

946
00:35:56,829 --> 00:35:54,400
really considered a breakthrough in our

947
00:35:58,630 --> 00:35:56,839
understanding of the physics of the

948
00:36:01,670 --> 00:35:58,640
universe

949
00:36:04,630 --> 00:36:01,680
now over the last 10 or 15 years

950
00:36:05,589 --> 00:36:04,640
improved data and now a wider range of

951
00:36:07,430 --> 00:36:05,599
techniques

952
00:36:09,349 --> 00:36:07,440
for mapping the expansion history of the

953
00:36:12,390 --> 00:36:09,359
universe not just supernovae

954
00:36:14,069 --> 00:36:12,400
but we can also use uh the radiation

955
00:36:16,870 --> 00:36:14,079
left over from the big bang

956
00:36:18,069 --> 00:36:16,880
and certain characteristic spots or spot

957
00:36:20,310 --> 00:36:18,079
sizes

958
00:36:21,270 --> 00:36:20,320
in the cosmic microwave background which

959
00:36:24,950 --> 00:36:21,280
today

960
00:36:26,470 --> 00:36:24,960
uh delineate the separations of galaxies

961
00:36:28,390 --> 00:36:26,480
are used to measure the expansion

962
00:36:29,190 --> 00:36:28,400
history of the universe and show us that

963
00:36:31,349 --> 00:36:29,200

we live

964
00:36:34,069 --> 00:36:31,359
in an era that is dominated by dark

965
00:36:35,990 --> 00:36:34,079
energy today causing the acceleration

966
00:36:38,069 --> 00:36:36,000
but was dominated in the past by dark

967
00:36:39,109 --> 00:36:38,079
matter causing it to decelerate even

968
00:36:42,390 --> 00:36:39,119
earlier

969
00:36:44,710 --> 00:36:42,400
understanding why or

970
00:36:45,670 --> 00:36:44,720
what exactly this dark energy is that

971
00:36:47,910 --> 00:36:45,680
makes up 70

972
00:36:49,910 --> 00:36:47,920
of the universe and what the dark matter

973
00:36:52,150 --> 00:36:49,920
is that makes up another 25

974
00:36:53,109 --> 00:36:52,160
is certainly uh one of if not the

975
00:36:55,430 --> 00:36:53,119
leading question

976
00:36:56,470 --> 00:36:55,440
about the universe um and so just to

977
00:36:59,030 --> 00:36:56,480
briefly

978
00:37:00,710 --> 00:36:59,040
tell you we have a few ideas about what

979
00:37:02,310 --> 00:37:00,720
dark energy might be

980
00:37:04,550 --> 00:37:02,320
it might be very similar to what

981
00:37:06,230 --> 00:37:04,560
einstein had described what we would uh

982
00:37:08,390 --> 00:37:06,240
in a more physics-based way

983
00:37:10,230 --> 00:37:08,400
describe as a static dark energy that

984
00:37:12,870 --> 00:37:10,240
there is inherently

985
00:37:14,550 --> 00:37:12,880
energy in empty space this is a feature

986
00:37:17,270 --> 00:37:14,560
really of quantum theory

987
00:37:17,589 --> 00:37:17,280
and in einstein's general relativity

988
00:37:19,589 --> 00:37:17,599

such

989
00:37:21,510 --> 00:37:19,599
energy would cause repulsive gravity

990
00:37:23,349 --> 00:37:21,520
however there's a terrible

991
00:37:25,670 --> 00:37:23,359
quantitative mismatch between these two

992
00:37:27,670 --> 00:37:25,680
ideas that makes us really struggle to

993
00:37:30,150 --> 00:37:27,680
accept this as a possibility

994
00:37:30,710 --> 00:37:30,160
another possibility is that this uh dark

995
00:37:33,190 --> 00:37:30,720
energy

996
00:37:35,829 --> 00:37:33,200
is due to a field in space and it's

997
00:37:38,310 --> 00:37:35,839
therefore a temporary phenomenon

998
00:37:40,150 --> 00:37:38,320
and so if we could map the expansion

999
00:37:41,990 --> 00:37:40,160
history in exquisite detail

1000
00:37:44,069 --> 00:37:42,000
we can distinguish between these two

1001
00:37:46,630 --> 00:37:44,079
possibilities static dark energy

1002
00:37:49,030 --> 00:37:46,640
or changing dark energy or even whether

1003
00:37:50,950 --> 00:37:49,040
our theory of gravity general relativity

1004
00:37:53,750 --> 00:37:50,960
even applies to dark energy whether we

1005
00:37:56,230 --> 00:37:53,760
have actually discovered and said a flaw

1006
00:37:57,910 --> 00:37:56,240
in the theory of gravity and so

1007
00:38:00,710 --> 00:37:57,920
certainly better measurements

1008
00:38:01,750 --> 00:38:00,720
of the expansion history over the last

1009
00:38:03,430 --> 00:38:01,760
few billion years

1010
00:38:05,270 --> 00:38:03,440
are really critical to discriminate

1011
00:38:07,510 --> 00:38:05,280
between these possibilities

1012
00:38:09,750 --> 00:38:07,520
if this wasn't already challenging

1013
00:38:12,710 --> 00:38:09,760

enough in the last few years we've seen

1014
00:38:14,550 --> 00:38:12,720
another sort of riddle uh arise sort of

1015
00:38:17,750 --> 00:38:14,560
a riddle wrapped in an enigma

1016
00:38:20,710 --> 00:38:17,760
as they say that when we look

1017
00:38:22,870 --> 00:38:20,720
even with the best uh observations we

1018
00:38:25,349 --> 00:38:22,880
have today of the expansion history

1019
00:38:26,870 --> 00:38:25,359
and we compare how fast the universe

1020
00:38:29,270 --> 00:38:26,880
ought to be expanding today

1021
00:38:30,470 --> 00:38:29,280
based on the observations of the cosmic

1022
00:38:32,870 --> 00:38:30,480
microwave background

1023
00:38:34,710 --> 00:38:32,880
versus direct measurements of this

1024
00:38:36,550 --> 00:38:34,720
quantity we call the hubble constant

1025
00:38:38,470 --> 00:38:36,560
we're starting to see a tension or

1026
00:38:41,430 --> 00:38:38,480
disagreement between these

1027
00:38:42,390 --> 00:38:41,440
uh what it belies we're not sure uh it

1028
00:38:44,150 --> 00:38:42,400
raises questions

1029
00:38:46,150 --> 00:38:44,160
how well do we know the age of the

1030
00:38:48,710 --> 00:38:46,160
universe and what are we missing

1031
00:38:49,750 --> 00:38:48,720
is this indeed this this discrepancy

1032
00:38:51,670 --> 00:38:49,760
that's showing up

1033
00:38:53,829 --> 00:38:51,680
one of the clues we've been looking for

1034
00:38:56,470 --> 00:38:53,839
about the nature of dark energy

1035
00:38:58,150 --> 00:38:56,480
or uh you know exactly what is going on

1036
00:39:00,790 --> 00:38:58,160
it's not clear

1037
00:39:02,550 --> 00:39:00,800
when one looks at the universe from the

1038
00:39:04,150 --> 00:39:02,560

beginning to the end or from the end to

1039
00:39:06,390 --> 00:39:04,160
the beginning the two paths

1040
00:39:08,470 --> 00:39:06,400
uh that are disagreeing we ought to get

1041
00:39:10,390 --> 00:39:08,480
the same answer and so this sort of

1042
00:39:12,069 --> 00:39:10,400
cosmological roshaman is very much on

1043
00:39:14,550 --> 00:39:12,079
our minds as we pursue

1044
00:39:16,150 --> 00:39:14,560
uh this next stage of adventure and so

1045
00:39:17,990 --> 00:39:16,160
as julie described

1046
00:39:20,069 --> 00:39:18,000
roman has a field of view that is a

1047
00:39:21,910 --> 00:39:20,079
hundred times greater than hubble

1048
00:39:23,829 --> 00:39:21,920
though because of other observing

1049
00:39:25,430 --> 00:39:23,839
efficiencies it's more like a factor of

1050
00:39:27,670 --> 00:39:25,440
a thousand in our

1051
00:39:29,670 --> 00:39:27,680
speed at which we can gather the kinds

1052
00:39:30,470 --> 00:39:29,680
of measurements that map the expansion

1053
00:39:32,630 --> 00:39:30,480
history

1054
00:39:34,390 --> 00:39:32,640
of the universe and we really look

1055
00:39:37,430 --> 00:39:34,400
forward to just probably in the first

1056
00:39:39,589 --> 00:39:37,440
year of using roman to surpass all the

1057
00:39:41,990 --> 00:39:39,599
work we've done over the last 20 years

1058
00:39:44,150 --> 00:39:42,000
and get a greater handle on the

1059
00:39:46,390 --> 00:39:44,160
expansion rate

1060
00:39:47,589 --> 00:39:46,400
roman will make use of a number of

1061
00:39:49,589 --> 00:39:47,599
techniques through the

1062
00:39:50,950 --> 00:39:49,599
accelerating era and the previous

1063
00:39:52,870 --> 00:39:50,960

decelerating era

1064
00:39:54,069 --> 00:39:52,880
including the supernova distances i

1065
00:39:56,069 --> 00:39:54,079
described

1066
00:39:58,710 --> 00:39:56,079
exquisite measurements of the shapes of

1067
00:40:01,349 --> 00:39:58,720
galaxies uh these spot sizes

1068
00:40:02,310 --> 00:40:01,359
uh lit up by the distribution of

1069
00:40:05,190 --> 00:40:02,320
galaxies

1070
00:40:06,230 --> 00:40:05,200
uh and other measures many of these are

1071
00:40:08,470 --> 00:40:06,240
complementary

1072
00:40:09,750 --> 00:40:08,480
or can sort of cross-check each other to

1073
00:40:11,589 --> 00:40:09,760
make sure that we get the kind of

1074
00:40:12,790 --> 00:40:11,599
precision information we need

1075
00:40:15,270 --> 00:40:12,800
to separate these different

1076
00:40:16,470 --> 00:40:15,280
possibilities so i'll just close with a

1077
00:40:17,990 --> 00:40:16,480
reminder

1078
00:40:20,069 --> 00:40:18,000
why it's so important to us to

1079
00:40:20,870 --> 00:40:20,079
understand the expansion history of the

1080
00:40:24,230 --> 00:40:20,880
universe

1081
00:40:27,750 --> 00:40:24,240
uh and it's really because 95 of it

1082
00:40:30,069 --> 00:40:27,760
is caused by the gravity of unseen stuff

1083
00:40:30,870 --> 00:40:30,079
and this is very profound very

1084
00:40:34,150 --> 00:40:30,880
significant

1085
00:40:35,589 --> 00:40:34,160
and because explaining it requires us to

1086
00:40:37,750 --> 00:40:35,599
understand physics

1087
00:40:40,069 --> 00:40:37,760
uh theories that really are incompatible

1088
00:40:40,630 --> 00:40:40,079

we hope that uh this clue from nature

1089
00:40:43,190 --> 00:40:40,640
about

1090
00:40:44,870 --> 00:40:43,200
how it does physics at the the interface

1091
00:40:46,790 --> 00:40:44,880
between incompatible theories

1092
00:40:48,150 --> 00:40:46,800
will teach us more about the physics of

1093
00:40:50,870 --> 00:40:48,160
the universe and so

1094
00:40:55,829 --> 00:40:50,880
i will end there and uh go on to the

1095
00:41:00,550 --> 00:40:59,510
thank you adam all right so our next

1096
00:41:02,470 --> 00:41:00,560
speaker is dr

1097
00:41:03,990 --> 00:41:02,480
rachel somerville who will be telling us

1098
00:41:07,190 --> 00:41:04,000
about galaxies across

1099
00:41:10,390 --> 00:41:07,200
cosmic time

1100
00:41:14,790 --> 00:41:10,400
thank you very much thanks for

1101
00:41:18,150 --> 00:41:14,800
inviting me to participate in this event

1102
00:41:19,109 --> 00:41:18,160
i am very excited to tell you about some

1103
00:41:22,390 --> 00:41:19,119
of the

1104
00:41:26,309 --> 00:41:22,400
science that roman will do

1105
00:41:36,069 --> 00:41:26,319
to constrain galaxy evolution okay

1106
00:41:42,630 --> 00:41:39,190
are you seeing my slide

1107
00:41:47,270 --> 00:41:42,640
yes thank you wonderful okay

1108
00:41:50,470 --> 00:41:47,280
um so

1109
00:41:54,069 --> 00:41:50,480
we have a baby picture of the universe

1110
00:41:54,790 --> 00:41:54,079
as it was about 380 000 years after the

1111
00:41:56,790 --> 00:41:54,800
big bang

1112
00:41:58,950 --> 00:41:56,800
we call this the cosmic microwave

1113
00:42:01,430 --> 00:41:58,960

background radiation

1114
00:42:02,069 --> 00:42:01,440
and that baby picture reveals that at

1115
00:42:05,349 --> 00:42:02,079
that early

1116
00:42:07,990 --> 00:42:05,359
time the universe was extremely simple

1117
00:42:09,670 --> 00:42:08,000
so it could be described by just a few

1118
00:42:13,990 --> 00:42:09,680
numbers

1119
00:42:15,990 --> 00:42:14,000
now if we fast forward about 13.7

1120
00:42:17,670 --> 00:42:16,000
billion years and look around the

1121
00:42:19,990 --> 00:42:17,680
present day universe

1122
00:42:20,870 --> 00:42:20,000
of course we see structures of amazing

1123
00:42:24,630 --> 00:42:20,880
complexity

1124
00:42:26,710 --> 00:42:24,640
such as galaxies walls of galaxies

1125
00:42:28,150 --> 00:42:26,720
filaments of galaxies clusters of

1126
00:42:32,230 --> 00:42:28,160
galaxies

1127
00:42:34,630 --> 00:42:32,240
stars planets mountains trees etc so

1128
00:42:35,670 --> 00:42:34,640
one way of phrasing sort of the big

1129
00:42:38,309 --> 00:42:35,680
question

1130
00:42:39,510 --> 00:42:38,319
um that is a huge challenge for

1131
00:42:42,390 --> 00:42:39,520
astrophysics

1132
00:42:43,510 --> 00:42:42,400
is how this complexity arose in the

1133
00:42:45,190 --> 00:42:43,520
universe

1134
00:42:46,550 --> 00:42:45,200
and one way that i like to think about

1135
00:42:49,349 --> 00:42:46,560
it is can we

1136
00:42:51,589 --> 00:42:49,359
sort of decode the physical processes

1137
00:42:55,829 --> 00:42:51,599
that imprinted that complexity

1138
00:42:58,870 --> 00:42:55,839

onto the universe so this is a very

1139
00:43:01,510 --> 00:42:58,880
lightning tour of

1140
00:43:03,990 --> 00:43:01,520
uh sort of our modern picture of how

1141
00:43:05,670 --> 00:43:04,000
galaxy formation works in a cosmological

1142
00:43:07,670 --> 00:43:05,680
context

1143
00:43:08,790 --> 00:43:07,680
so from theoretical and numerical

1144
00:43:11,190 --> 00:43:08,800
calculations

1145
00:43:11,990 --> 00:43:11,200
we know that the dark matter and normal

1146
00:43:15,349 --> 00:43:12,000
matter

1147
00:43:16,069 --> 00:43:15,359
in the universe had some very small

1148
00:43:17,670 --> 00:43:16,079
lumps

1149
00:43:19,670 --> 00:43:17,680
in this early universe that we saw on

1150
00:43:22,390 --> 00:43:19,680
the cosmic microwave background

1151
00:43:24,470 --> 00:43:22,400
and over time as the universe expanded

1152
00:43:25,990 --> 00:43:24,480
gravity was a little bit stronger

1153
00:43:28,630 --> 00:43:26,000
wherever there was a little bit more

1154
00:43:29,990 --> 00:43:28,640
matter and so that caused matter to

1155
00:43:32,150 --> 00:43:30,000
clump together

1156
00:43:33,670 --> 00:43:32,160
under the force of gravity and form

1157
00:43:35,910 --> 00:43:33,680
gravitationally bound

1158
00:43:37,589 --> 00:43:35,920
structures so clumps of matter that were

1159
00:43:40,630 --> 00:43:37,599
not expanding anymore

1160
00:43:43,589 --> 00:43:40,640
that were held together by gravity

1161
00:43:45,510 --> 00:43:43,599
and inside of those cosmic structures

1162
00:43:48,550 --> 00:43:45,520
those bound structures

1163
00:43:51,589 --> 00:43:48,560

gas could accrete and cool down

1164
00:43:52,390 --> 00:43:51,599
and when gas cools down it falls to the

1165
00:43:55,349 --> 00:43:52,400
center

1166
00:43:56,069 --> 00:43:55,359
of the potential well and it can cool

1167
00:43:59,349 --> 00:43:56,079
off

1168
00:44:02,630 --> 00:43:59,359
and begin to form stars

1169
00:44:05,829 --> 00:44:02,640
now some of that gas may even

1170
00:44:08,150 --> 00:44:05,839
be able to accrete far far down into the

1171
00:44:11,349 --> 00:44:08,160
very center of the galaxy

1172
00:44:13,349 --> 00:44:11,359
where it may feed a supermassive black

1173
00:44:16,710 --> 00:44:13,359
hole

1174
00:44:19,030 --> 00:44:16,720
however once stars start to form

1175
00:44:20,309 --> 00:44:19,040
and once black holes start to accrete

1176
00:44:23,670 --> 00:44:20,319
both of those

1177
00:44:26,150 --> 00:44:23,680
can produce energetic radiation and that

1178
00:44:29,270 --> 00:44:26,160
radiation can heat the gas back up

1179
00:44:31,349 --> 00:44:29,280
and it can even push the gas out of

1180
00:44:33,349 --> 00:44:31,359
the center of the galaxy or even out of

1181
00:44:36,550 --> 00:44:33,359
the galaxy altogether so

1182
00:44:37,829 --> 00:44:36,560
we sometimes call this the cosmic baryon

1183
00:44:41,829 --> 00:44:37,839
cycle

1184
00:44:44,790 --> 00:44:41,839
gas is

1185
00:44:45,990 --> 00:44:44,800
falling in making stars and then cycling

1186
00:44:50,150 --> 00:44:46,000
back out and back

1187
00:44:53,349 --> 00:44:50,160
back in again

1188
00:44:53,670 --> 00:44:53,359

so um i'm going to present you with sort

1189
00:44:57,030 --> 00:44:53,680
of

1190
00:44:59,910 --> 00:44:57,040
think roman

1191
00:45:00,309 --> 00:44:59,920
will be able to help us answer and the

1192
00:45:03,710 --> 00:45:00,319
first

1193
00:45:04,950 --> 00:45:03,720
question has to do with a process called

1194
00:45:07,109 --> 00:45:04,960
re-ionization

1195
00:45:08,150 --> 00:45:07,119
now this is one of the strange

1196
00:45:11,750 --> 00:45:08,160
terminology

1197
00:45:15,430 --> 00:45:11,760
quirks in astrophysics

1198
00:45:21,190 --> 00:45:15,440
so in the very early universe

1199
00:45:24,230 --> 00:45:23,430
ionized so all of the protons and

1200
00:45:26,550 --> 00:45:24,240
electrons were

1201
00:45:27,990 --> 00:45:26,560
were separated but then as the universe

1202
00:45:29,670 --> 00:45:28,000
cooled down

1203
00:45:31,829 --> 00:45:29,680
uh the protons and the electrons

1204
00:45:34,069 --> 00:45:31,839
combined to form neutral atoms of

1205
00:45:36,710 --> 00:45:34,079
hydrogen and then there was a long

1206
00:45:39,829 --> 00:45:36,720
period that we call the dark ages

1207
00:45:41,829 --> 00:45:39,839
up until about uh

1208
00:45:43,030 --> 00:45:41,839
one or two hundred mil million years

1209
00:45:45,589 --> 00:45:43,040
after the big bang

1210
00:45:46,950 --> 00:45:45,599
when the first stars formed and those

1211
00:45:50,790 --> 00:45:46,960
first stars

1212
00:45:54,470 --> 00:45:50,800
produced photons that then could

1213
00:45:57,750 --> 00:45:54,480

again ionize the hydrogen

1214
00:45:58,710 --> 00:45:57,760
and so you could sort of visualize these

1215
00:46:01,510 --> 00:45:58,720
bubbles

1216
00:46:04,069 --> 00:46:01,520
of ionized hydrogen that would expand

1217
00:46:07,109 --> 00:46:04,079
outwards and eventually overlap

1218
00:46:09,109 --> 00:46:07,119
and since about

1219
00:46:10,710 --> 00:46:09,119
redshift six or so about a billion years

1220
00:46:11,589 --> 00:46:10,720
after the big bang we know that most of

1221
00:46:14,150 --> 00:46:11,599
the hydrogen

1222
00:46:15,829 --> 00:46:14,160
in the universe is ionized so the

1223
00:46:18,309 --> 00:46:15,839
question is

1224
00:46:20,390 --> 00:46:18,319
what sources produced these photons that

1225
00:46:22,470 --> 00:46:20,400
caused this process to occur

1226
00:46:23,510 --> 00:46:22,480
and how are those sources distributed in

1227
00:46:26,069 --> 00:46:23,520
space

1228
00:46:28,630 --> 00:46:26,079
we think we may be able to measure the

1229
00:46:29,589 --> 00:46:28,640
topology of these bubbles using radio

1230
00:46:31,750 --> 00:46:29,599
telescopes

1231
00:46:32,870 --> 00:46:31,760
and so it would be very exciting to be

1232
00:46:35,349 --> 00:46:32,880
able to map

1233
00:46:37,270 --> 00:46:35,359
the visible galaxies as we will be able

1234
00:46:41,270 --> 00:46:37,280
to do with the roman space telescope

1235
00:46:44,870 --> 00:46:41,280
and understand how they map onto

1236
00:46:49,510 --> 00:46:47,670
so another question i mentioned that

1237
00:46:51,349 --> 00:46:49,520
black holes may be able to form in the

1238
00:46:54,069 --> 00:46:51,359

centers of galaxies

1239
00:46:56,550 --> 00:46:54,079
is how did the very first black holes

1240
00:46:59,510 --> 00:46:56,560
form in the very early universe

1241
00:47:00,470 --> 00:46:59,520
and how does the environment around

1242
00:47:03,910 --> 00:47:00,480
those black holes

1243
00:47:05,750 --> 00:47:03,920
affect how rapidly they can grow

1244
00:47:07,030 --> 00:47:05,760
and then remember i mentioned that black

1245
00:47:10,150 --> 00:47:07,040
holes can cause

1246
00:47:12,790 --> 00:47:10,160
what we call a feedback process where

1247
00:47:14,230 --> 00:47:12,800
as soon as they start to grow they

1248
00:47:17,349 --> 00:47:14,240
essentially can

1249
00:47:18,630 --> 00:47:17,359
suppress further growth of the black

1250
00:47:21,030 --> 00:47:18,640
hole itself

1251
00:47:21,750 --> 00:47:21,040
as well as growth of the galaxy around

1252
00:47:25,430 --> 00:47:21,760
it

1253
00:47:28,630 --> 00:47:25,440
so what you see in the bottom

1254
00:47:30,950 --> 00:47:28,640
image here is a computer simulation

1255
00:47:32,470 --> 00:47:30,960
of the formation of structure galaxies

1256
00:47:35,510 --> 00:47:32,480
in black holes

1257
00:47:35,910 --> 00:47:35,520
by my collaborator melanie abusee and

1258
00:47:39,030 --> 00:47:35,920
each

1259
00:47:41,109 --> 00:47:39,040
x marks the location of a black hole so

1260
00:47:42,790 --> 00:47:41,119
you can see in the left panel here

1261
00:47:44,710 --> 00:47:42,800
that this black hole is in the middle of

1262
00:47:46,390 --> 00:47:44,720
a very dense structure with many many

1263
00:47:48,390 --> 00:47:46,400

galaxies around it

1264
00:47:49,430 --> 00:47:48,400
while on the right panel the black hole

1265
00:47:51,430 --> 00:47:49,440
has formed

1266
00:47:53,270 --> 00:47:51,440
in almost a void there are very few

1267
00:47:55,430 --> 00:47:53,280
other galaxies around it

1268
00:47:56,950 --> 00:47:55,440
now these massive black holes in the

1269
00:47:59,910 --> 00:47:56,960
early universe

1270
00:48:01,030 --> 00:47:59,920
are quite rare and so you need to be

1271
00:48:04,309 --> 00:48:01,040
able to survey

1272
00:48:06,230 --> 00:48:04,319
over very large areas in order to study

1273
00:48:08,549 --> 00:48:06,240
these relatively rare objects and this

1274
00:48:11,109 --> 00:48:08,559
is something that the roman telescope

1275
00:48:12,470 --> 00:48:11,119
will be able to do and tell us about how

1276
00:48:17,190 --> 00:48:12,480
black holes formed

1277
00:48:23,510 --> 00:48:20,309
so if we look at images of galaxies

1278
00:48:26,630 --> 00:48:23,520
in the nearby universe we see that they

1279
00:48:28,549 --> 00:48:26,640
have different shapes so many of you are

1280
00:48:30,870 --> 00:48:28,559
probably familiar with

1281
00:48:31,990 --> 00:48:30,880
spiral galaxies like our own milky way

1282
00:48:34,870 --> 00:48:32,000
galaxy

1283
00:48:36,950 --> 00:48:34,880
or you may have seen images of

1284
00:48:38,069 --> 00:48:36,960
elliptical galaxies which are these sort

1285
00:48:41,430 --> 00:48:38,079
of football

1286
00:48:42,870 --> 00:48:41,440
roundish galaxies and of course there's

1287
00:48:46,150 --> 00:48:42,880
enormous variety

1288
00:48:47,270 --> 00:48:46,160

within these these categories

1289
00:48:49,589 --> 00:48:47,280
but there are some interesting

1290
00:48:52,870 --> 00:48:49,599
correlations between

1291
00:48:56,390 --> 00:48:52,880
the galaxy's shape or morphology

1292
00:48:59,270 --> 00:48:56,400
and the stars inside the galaxy

1293
00:49:00,069 --> 00:48:59,280
so these spiral galaxies tend to have

1294
00:49:03,589 --> 00:49:00,079
stars

1295
00:49:06,549 --> 00:49:03,599
with blue colors that are quite young

1296
00:49:07,750 --> 00:49:06,559
while the elliptical galaxies tend to

1297
00:49:11,030 --> 00:49:07,760
have stars

1298
00:49:14,069 --> 00:49:11,040
that have red colors and are quite old

1299
00:49:16,790 --> 00:49:14,079
so there's a connection between the

1300
00:49:19,349 --> 00:49:16,800
galaxy's structure or morphology

1301
00:49:20,390 --> 00:49:19,359
and the stars that live inside of that

1302
00:49:22,470 --> 00:49:20,400
galaxy

1303
00:49:23,430 --> 00:49:22,480
and the physics that drives that

1304
00:49:27,030 --> 00:49:23,440
connection

1305
00:49:29,510 --> 00:49:27,040
is still not completely worked out

1306
00:49:30,630 --> 00:49:29,520
but then beyond that there's a

1307
00:49:33,910 --> 00:49:30,640
connection

1308
00:49:36,710 --> 00:49:33,920
between the type of galaxy

1309
00:49:38,630 --> 00:49:36,720
and it's its contents and its

1310
00:49:41,510 --> 00:49:38,640
large-scale environment

1311
00:49:44,230 --> 00:49:41,520
so um on the bottom right here is a

1312
00:49:46,710 --> 00:49:44,240
diagram of the locations of galaxies

1313
00:49:47,750 --> 00:49:46,720

in space from the sloan digital sky

1314
00:49:49,990 --> 00:49:47,760
survey

1315
00:49:52,630 --> 00:49:50,000
and you can see again that the galaxies

1316
00:49:55,829 --> 00:49:52,640
trace out these very large structures

1317
00:49:59,750 --> 00:49:55,839
so the the structures here

1318
00:50:01,589 --> 00:49:59,760
have scales of billions of light years

1319
00:50:03,829 --> 00:50:01,599
and you the colors here represent the

1320
00:50:05,430 --> 00:50:03,839
colors of the stars in the galaxies that

1321
00:50:06,710 --> 00:50:05,440
are tracing out these structures and so

1322
00:50:09,829 --> 00:50:06,720
again you can see

1323
00:50:12,710 --> 00:50:09,839
that the red galaxies tend to live in

1324
00:50:15,430 --> 00:50:12,720
these very dense regions of the universe

1325
00:50:18,150 --> 00:50:15,440
sort of the urban areas of the universe

1326
00:50:20,069 --> 00:50:18,160
while the blue galaxies are sort of more

1327
00:50:24,069 --> 00:50:20,079
uniformly spread out

1328
00:50:25,030 --> 00:50:24,079
living in the suburbs so the third big

1329
00:50:27,349 --> 00:50:25,040
question

1330
00:50:29,349 --> 00:50:27,359
is how the physical processes that have

1331
00:50:32,630 --> 00:50:29,359
shaped galaxy formation

1332
00:50:35,030 --> 00:50:32,640
over the last 13.8 billion years

1333
00:50:36,069 --> 00:50:35,040
have interacted across this vast range

1334
00:50:38,549 --> 00:50:36,079
of scales

1335
00:50:40,390 --> 00:50:38,559
from individual stars and black holes

1336
00:50:41,109 --> 00:50:40,400
which have sizes of less than a light

1337
00:50:42,790 --> 00:50:41,119
year

1338
00:50:44,309 --> 00:50:42,800

all the way out to these scales of

1339
00:50:47,510 --> 00:50:44,319
hundreds of thousands

1340
00:50:50,069 --> 00:50:47,520
to billions of light years

1341
00:50:52,549 --> 00:50:50,079
and so one reason that the roman space

1342
00:50:54,630 --> 00:50:52,559
telescope will be so transformational

1343
00:50:56,230 --> 00:50:54,640
is because of this combination that we

1344
00:50:59,990 --> 00:50:56,240
already heard about

1345
00:51:01,910 --> 00:51:00,000
of the high fidelity the high resolution

1346
00:51:03,510 --> 00:51:01,920
the sharpness of the image

1347
00:51:05,430 --> 00:51:03,520
and which you can see here will be

1348
00:51:07,510 --> 00:51:05,440
similar to what we

1349
00:51:09,190 --> 00:51:07,520
were able to obtain with a hubble space

1350
00:51:10,790 --> 00:51:09,200
telescope here in the hubble alternate

1351
00:51:12,549 --> 00:51:10,800
field so you can see

1352
00:51:15,270 --> 00:51:12,559
what type of galaxy it is what is the

1353
00:51:18,549 --> 00:51:15,280
galaxy structure

1354
00:51:20,950 --> 00:51:18,559
while simultaneously being able to map

1355
00:51:22,950 --> 00:51:20,960
large numbers of galaxies over these

1356
00:51:26,150 --> 00:51:22,960
vast areas and so study

1357
00:51:28,870 --> 00:51:26,160
this connection across this huge range

1358
00:51:31,190 --> 00:51:28,880
of spatial scales

1359
00:51:32,549 --> 00:51:31,200
so i will leave you with a summary of my

1360
00:51:41,030 --> 00:51:32,559
questions

1361
00:51:41,040 --> 00:51:44,950
thank you rachel

1362
00:51:50,790 --> 00:51:48,549
okay so um now we are going to

1363
00:51:52,630 --> 00:51:50,800

have our final presentation of the

1364
00:51:56,069 --> 00:51:52,640
workshop which will be followed by q

1365
00:51:57,109 --> 00:51:56,079
a and that presentation is by dr harry

1366
00:51:58,950 --> 00:51:57,119
ferguson

1367
00:52:05,829 --> 00:51:58,960
who will be telling us about science

1368
00:52:07,990 --> 00:52:05,839
synergies of the 2020s

1369
00:52:11,030 --> 00:52:08,000
all right can you see my screen and can

1370
00:52:14,870 --> 00:52:14,069
yes and yes thank you all right uh well

1371
00:52:16,870 --> 00:52:14,880
thank you very much

1372
00:52:18,390 --> 00:52:16,880
uh it's a pleasure to follow all the

1373
00:52:19,670 --> 00:52:18,400
other speakers here um

1374
00:52:21,990 --> 00:52:19,680
so i'm going to try to step back a

1375
00:52:25,109 --> 00:52:22,000
little bit from

1376
00:52:27,990 --> 00:52:25,119
the detailed science and just try to put

1377
00:52:29,349 --> 00:52:28,000
roman in context with other facilities

1378
00:52:31,510 --> 00:52:29,359
that are coming online

1379
00:52:32,870 --> 00:52:31,520
uh pretty soon of course hubble's been

1380
00:52:36,069 --> 00:52:32,880
online for quite a while

1381
00:52:37,589 --> 00:52:36,079
and roman is a uh worthy successor to

1382
00:52:40,150 --> 00:52:37,599
hubble in many ways

1383
00:52:40,950 --> 00:52:40,160
um the james webb telescope which will

1384
00:52:43,750 --> 00:52:40,960
be launched

1385
00:52:45,990 --> 00:52:43,760
uh in a few years uh let's hope that

1386
00:52:48,710 --> 00:52:46,000
covet doesn't delay it any longer

1387
00:52:49,589 --> 00:52:48,720
so maybe next year maybe the year after

1388
00:52:52,390 --> 00:52:49,599

um

1389
00:52:53,430 --> 00:52:52,400
and it it is also a successor to hubble

1390
00:52:57,190 --> 00:52:53,440
in many ways

1391
00:52:58,870 --> 00:52:57,200
um and uh so i'll describe that a little

1392
00:53:01,990 --> 00:52:58,880
bit

1393
00:53:03,349 --> 00:53:02,000
and um then there are a bunch of other

1394
00:53:06,870 --> 00:53:03,359
facilities and i will

1395
00:53:10,309 --> 00:53:06,880
uh focus on a few of them i i added

1396
00:53:12,309 --> 00:53:10,319
one so across the top of this diagram

1397
00:53:14,630 --> 00:53:12,319
uh shows the electromagnetic spectrum

1398
00:53:16,870 --> 00:53:14,640
running from the gamma rays to the radio

1399
00:53:17,750 --> 00:53:16,880
and the facilities are placed at sort of

1400
00:53:21,829 --> 00:53:17,760
roughly

1401
00:53:25,190 --> 00:53:21,839
the place where they are observing

1402
00:53:26,790 --> 00:53:25,200
um and uh so you can see things uh

1403
00:53:28,309 --> 00:53:26,800
stretching from the gamma rays down to

1404
00:53:30,950 --> 00:53:28,319
the radio

1405
00:53:32,710 --> 00:53:30,960
i added ligo which does not observe at

1406
00:53:34,150 --> 00:53:32,720
electromagnetic frequencies that's down

1407
00:53:35,990 --> 00:53:34,160
in the lower left

1408
00:53:38,230 --> 00:53:36,000
but is extremely exciting observing

1409
00:53:39,910 --> 00:53:38,240
gravitational waves for the first time

1410
00:53:42,309 --> 00:53:39,920
and of course following them up

1411
00:53:42,950 --> 00:53:42,319
electromagnetic in the electromagnetic

1412
00:53:45,750 --> 00:53:42,960
spectrum

1413
00:53:47,270 --> 00:53:45,760

is a is a big science goal for many of

1414
00:53:50,230 --> 00:53:47,280
these facilities

1415
00:53:51,190 --> 00:53:50,240
um i'm going to focus mostly on roman

1416
00:53:55,750 --> 00:53:51,200
webb

1417
00:53:58,470 --> 00:53:55,760
um the reuben observatory um yeah

1418
00:53:59,190 --> 00:53:58,480
and um the euclid observatory a little

1419
00:54:02,309 --> 00:53:59,200
bit

1420
00:54:04,230 --> 00:54:02,319
um coming online as well on the ground

1421
00:54:06,150 --> 00:54:04,240
sometime in the decade are extremely

1422
00:54:07,190 --> 00:54:06,160
large telescopes which i won't talk very

1423
00:54:10,710 --> 00:54:07,200
much about

1424
00:54:12,390 --> 00:54:10,720
uh but those uh have the light gathering

1425
00:54:13,109 --> 00:54:12,400
power that will exceed any of the other

1426
00:54:14,870 --> 00:54:13,119
ones

1427
00:54:17,510 --> 00:54:14,880
uh but of course they're down on the

1428
00:54:20,630 --> 00:54:17,520
earth so have the atmosphere in the way

1429
00:54:21,670 --> 00:54:20,640
um so the uh astrophysics communities

1430
00:54:23,750 --> 00:54:21,680
around the world

1431
00:54:26,069 --> 00:54:23,760
uh do strategic planning sort of on a

1432
00:54:28,390 --> 00:54:26,079
decadal time scale

1433
00:54:29,990 --> 00:54:28,400
it's called the catal surveys in the u.s

1434
00:54:33,990 --> 00:54:30,000
and there was one done in

1435
00:54:36,710 --> 00:54:34,000
around 2000 another one done in 2010.

1436
00:54:37,990 --> 00:54:36,720
the highest priority space mission from

1437
00:54:41,349 --> 00:54:38,000
2000 was james webb

1438
00:54:43,349 --> 00:54:41,359

telescope uh in the 2010 decadal survey

1439
00:54:46,309 --> 00:54:43,359
the highest priority ground-based

1440
00:54:48,150 --> 00:54:46,319
facility was the uh what was called the

1441
00:54:49,670 --> 00:54:48,160
large synoptic survey telescope at the

1442
00:54:50,950 --> 00:54:49,680
time was renamed the vera rubin

1443
00:54:54,630 --> 00:54:50,960
observatory

1444
00:54:57,750 --> 00:54:54,640
and then um a mission that was um

1445
00:55:01,109 --> 00:54:57,760
that the word wfirst um was

1446
00:55:05,349 --> 00:55:01,119
coined by this committee um

1447
00:55:07,190 --> 00:55:05,359
a wide field infrared space telescope

1448
00:55:08,950 --> 00:55:07,200
was recently renamed the nancy grace

1449
00:55:12,069 --> 00:55:08,960
roman space telescope

1450
00:55:15,190 --> 00:55:12,079
european astronomy does a similar

1451
00:55:17,990 --> 00:55:15,200
strategic planning and out of

1452
00:55:18,950 --> 00:55:18,000
not only that planning but competitions

1453
00:55:20,309 --> 00:55:18,960
emerged

1454
00:55:21,990 --> 00:55:20,319
euclid mission which is very

1455
00:55:24,710 --> 00:55:22,000
complementary to

1456
00:55:25,910 --> 00:55:24,720
the other two wide field telescopes i

1457
00:55:30,789 --> 00:55:25,920
just talked about

1458
00:55:37,270 --> 00:55:35,589
ground-based telescope um

1459
00:55:39,670 --> 00:55:37,280
so i want to talk a little bit about

1460
00:55:42,309 --> 00:55:39,680
science themes because that's what

1461
00:55:43,990 --> 00:55:42,319
those decadal surveys look at to try to

1462
00:55:47,190 --> 00:55:44,000
decide what facilities

1463
00:55:48,309 --> 00:55:47,200

they have and so we heard from adam

1464
00:55:50,230 --> 00:55:48,319
reese among others

1465
00:55:51,670 --> 00:55:50,240
about the physics of universe and dark

1466
00:55:54,230 --> 00:55:51,680
energy in particular

1467
00:55:55,349 --> 00:55:54,240
and the various ways we have of trying

1468
00:55:57,589 --> 00:55:55,359
to get at

1469
00:55:59,589 --> 00:55:57,599
and do measurements that are relative to

1470
00:55:59,910 --> 00:55:59,599
understanding dark energy so type on

1471
00:56:02,789 --> 00:55:59,920
earth

1472
00:56:04,630 --> 00:56:02,799
on a supernova uh finding them and

1473
00:56:06,390 --> 00:56:04,640
measuring their light curves

1474
00:56:09,109 --> 00:56:06,400
at various distances gravitational

1475
00:56:09,910 --> 00:56:09,119
lensing baryon acoustic oscillations so

1476
00:56:12,950 --> 00:56:09,920
measuring the

1477
00:56:14,710 --> 00:56:12,960
pres the positions of galaxies um and

1478
00:56:17,430 --> 00:56:14,720
looking for the signal of clustering

1479
00:56:19,190 --> 00:56:17,440
in that in those positions and

1480
00:56:20,710 --> 00:56:19,200
velocities

1481
00:56:22,789 --> 00:56:20,720
measuring the growth of clusters of

1482
00:56:24,950 --> 00:56:22,799
galaxies are some of the major ways and

1483
00:56:27,510 --> 00:56:24,960
there are others

1484
00:56:28,470 --> 00:56:27,520
planetary systems are a big theme

1485
00:56:31,030 --> 00:56:28,480
looking for

1486
00:56:31,670 --> 00:56:31,040
external planetary systems via various

1487
00:56:37,430 --> 00:56:31,680
techniques

1488
00:56:40,950 --> 00:56:39,829

gravitational micro lensing so looking

1489
00:56:43,190 --> 00:56:40,960
for the effect

1490
00:56:45,589 --> 00:56:43,200
tiny effect relatively tiny effect of

1491
00:56:48,950 --> 00:56:45,599
gravitation of planets

1492
00:56:51,910 --> 00:56:48,960
passing in front of stars while they

1493
00:56:55,430 --> 00:56:51,920
pass in front of other stars

1494
00:56:58,069 --> 00:56:55,440
velocities of uh

1495
00:56:59,349 --> 00:56:58,079
of stars that have planets orbiting them

1496
00:57:01,589 --> 00:56:59,359
radial velocities

1497
00:57:03,349 --> 00:57:01,599
or positions the wobble if you can

1498
00:57:05,430 --> 00:57:03,359
observe measure very very precise

1499
00:57:07,190 --> 00:57:05,440
positions measure the wobble

1500
00:57:09,750 --> 00:57:07,200
that is induced in the position of the

1501
00:57:10,950 --> 00:57:09,760
star or look for the signature of

1502
00:57:14,150 --> 00:57:10,960
planets in the

1503
00:57:16,470 --> 00:57:14,160
dust and debris around other stars

1504
00:57:18,549 --> 00:57:16,480
or try to understand the formation of

1505
00:57:18,870 --> 00:57:18,559
planetary systems and our solar system

1506
00:57:21,750 --> 00:57:18,880
by

1507
00:57:24,069 --> 00:57:21,760
studying the debris left or left the

1508
00:57:26,230 --> 00:57:24,079
small bodies in our solar system

1509
00:57:29,030 --> 00:57:26,240
that were left there during the

1510
00:57:31,109 --> 00:57:29,040
formation of our own solar system

1511
00:57:32,549 --> 00:57:31,119
um and then rachel somerville talked

1512
00:57:34,549 --> 00:57:32,559
about cosmic dawn

1513
00:57:37,270 --> 00:57:34,559

and of course we have various ways of

1514
00:57:40,390 --> 00:57:37,280
trying to find and study galaxies so

1515
00:57:43,030 --> 00:57:40,400
just going out and measuring uh

1516
00:57:44,470 --> 00:57:43,040
taking images through various filters to

1517
00:57:46,549 --> 00:57:44,480
estimate colors

1518
00:57:48,230 --> 00:57:46,559
measure spectral features with a

1519
00:57:50,390 --> 00:57:48,240
spectrograph

1520
00:57:52,470 --> 00:57:50,400
look for supernovae that might be

1521
00:57:55,270 --> 00:57:52,480
signatures of the earliest stars the

1522
00:57:56,710 --> 00:57:55,280
the certain massive stars explode in

1523
00:57:57,990 --> 00:57:56,720
what's known as parent stability

1524
00:57:59,589 --> 00:57:58,000
supernova

1525
00:58:01,270 --> 00:57:59,599
they're rare enough that it takes a wide

1526
00:58:03,910 --> 00:58:01,280
field of view and a

1527
00:58:05,510 --> 00:58:03,920
long time monitoring to find them but

1528
00:58:08,870 --> 00:58:05,520
they may be among the most

1529
00:58:09,670 --> 00:58:08,880
um uh interesting signposts of the first

1530
00:58:12,069 --> 00:58:09,680
stars

1531
00:58:14,150 --> 00:58:12,079
in the universe if we can find them uh

1532
00:58:15,670 --> 00:58:14,160
intervening absorption lines so look for

1533
00:58:19,030 --> 00:58:15,680
a bright quasar

1534
00:58:22,150 --> 00:58:19,040
or sum up the spectra of bright galaxies

1535
00:58:23,990 --> 00:58:22,160
and look at the chemical composition

1536
00:58:25,829 --> 00:58:24,000
and velocities and so on of the

1537
00:58:28,150 --> 00:58:25,839
intermediate meeting

1538
00:58:29,990 --> 00:58:28,160

intervening intergalactic medium

1539
00:58:33,349 --> 00:58:30,000
absorbing some of the light

1540
00:58:35,270 --> 00:58:33,359
of those distant objects intensity

1541
00:58:36,470 --> 00:58:35,280
mapping of emission lines is a fairly

1542
00:58:39,270 --> 00:58:36,480
new field

1543
00:58:41,349 --> 00:58:39,280
it's part of what is motivating radio

1544
00:58:43,030 --> 00:58:41,359
surveys but it can also be done

1545
00:58:45,750 --> 00:58:43,040
at optical wavelengths and it's

1546
00:58:49,430 --> 00:58:45,760
basically trying to sum together

1547
00:58:51,349 --> 00:58:49,440
the sky in just in a very narrow

1548
00:58:54,549 --> 00:58:51,359
emission line and then look at

1549
00:58:56,549 --> 00:58:54,559
uh the clustering signal um to try to

1550
00:58:59,270 --> 00:58:56,559
map out filaments and so on in

1551
00:59:01,030 --> 00:58:59,280
um intensity of the mission lines uh and

1552
00:59:02,789 --> 00:59:01,040
then another way to get at the earliest

1553
00:59:04,870 --> 00:59:02,799
galaxies is to look at the

1554
00:59:06,230 --> 00:59:04,880
oldest stars nearby because those would

1555
00:59:09,190 --> 00:59:06,240
have been the ones that formed

1556
00:59:10,230 --> 00:59:09,200
the earliest so in the milky way or in

1557
00:59:13,270 --> 00:59:10,240
the close

1558
00:59:15,990 --> 00:59:13,280
environment of the milky way finally the

1559
00:59:17,430 --> 00:59:16,000
time domain is just an area of discovery

1560
00:59:19,030 --> 00:59:17,440
because we've really never had

1561
00:59:23,270 --> 00:59:19,040
facilities that can

1562
00:59:25,430 --> 00:59:23,280
cover as much of the sky as frequently

1563
00:59:27,670 --> 00:59:25,440

as we will have and this will allow us

1564
00:59:28,470 --> 00:59:27,680
to find black hole events not only from

1565
00:59:31,349 --> 00:59:28,480
time domain

1566
00:59:32,230 --> 00:59:31,359
surveys in the electromagnetic spectrum

1567
00:59:34,950 --> 00:59:32,240
but also from

1568
00:59:37,750 --> 00:59:34,960
gravitational waves um look for motions

1569
00:59:40,789 --> 00:59:37,760
of stars measure motions of stars

1570
00:59:43,829 --> 00:59:40,799
accurately um over long

1571
00:59:46,470 --> 00:59:43,839
time baselines microlensing

1572
00:59:48,230 --> 00:59:46,480
and explosions looking for supernovae or

1573
00:59:48,789 --> 00:59:48,240
other kinds of explosions maybe ones

1574
00:59:54,470 --> 00:59:48,799
that we

1575
00:59:55,910 --> 00:59:54,480
study the pulsations of stars so there's

1576
00:59:57,349 --> 00:59:55,920
all sorts of things we can do in the

1577
01:00:00,470 --> 00:59:57,359
time domain

1578
01:00:01,589 --> 01:00:00,480
with these facilities um so i just want

1579
01:00:03,349 --> 01:00:01,599
to briefly sort of run

1580
01:00:04,789 --> 01:00:03,359
through why we need all these different

1581
01:00:06,309 --> 01:00:04,799
facilities and basically

1582
01:00:08,150 --> 01:00:06,319
you can't build a telescope that does

1583
01:00:10,950 --> 01:00:08,160
everything so you have to build multiple

1584
01:00:12,390 --> 01:00:10,960
facilities one of the most uh important

1585
01:00:13,430 --> 01:00:12,400
ones is the field of view and we've

1586
01:00:16,710 --> 01:00:13,440
talked about that a bit

1587
01:00:19,990 --> 01:00:16,720
so far i want to mention

1588
01:00:23,109 --> 01:00:20,000

uh roman in context with some other

1589
01:00:26,870 --> 01:00:23,119
facilities so the the big

1590
01:00:29,430 --> 01:00:26,880
um blue squares

1591
01:00:31,510 --> 01:00:29,440
are the vera reuben observatory the gr

1592
01:00:33,510 --> 01:00:31,520
this big ground-based facility

1593
01:00:35,430 --> 01:00:33,520
which has a field of view much larger

1594
01:00:38,470 --> 01:00:35,440
than any of the others

1595
01:00:41,990 --> 01:00:38,480
um in fact uh it will be the largest uh

1596
01:00:45,510 --> 01:00:42,000
camera uh ever built um

1597
01:00:47,829 --> 01:00:45,520
and put in context are

1598
01:00:49,589 --> 01:00:47,839
the widest area survey that hubble has

1599
01:00:52,230 --> 01:00:49,599
done the cosmos survey

1600
01:00:53,109 --> 01:00:52,240
and a very wide deep one that i was

1601
01:00:54,789 --> 01:00:53,119
involved in

1602
01:00:57,430 --> 01:00:54,799
candle survey which took about three

1603
01:01:01,270 --> 01:00:57,440
months of hubble observing time spread

1604
01:01:04,950 --> 01:01:01,280
over three years so very major project

1605
01:01:07,030 --> 01:01:04,960
and the

1606
01:01:07,990 --> 01:01:07,040
lsst while it has this giant field of

1607
01:01:11,670 --> 01:01:08,000
view has a

1608
01:01:13,910 --> 01:01:11,680
relatively coarse uh pixel scale and

1609
01:01:15,589 --> 01:01:13,920
resolution so pixel scale of 0.2 arc

1610
01:01:18,630 --> 01:01:15,599
seconds per pixel and a

1611
01:01:21,190 --> 01:01:18,640
typical seeing of 0.6 um

1612
01:01:23,190 --> 01:01:21,200
the roman field of view fits inside that

1613
01:01:27,109 --> 01:01:23,200

so we can't cover with roman

1614
01:01:28,470 --> 01:01:27,119
nearly the area that lsst can cover in

1615
01:01:31,829 --> 01:01:28,480
one grasp

1616
01:01:34,470 --> 01:01:31,839
uh one one one shot but um

1617
01:01:35,589 --> 01:01:34,480
of course we get a finer image in

1618
01:01:40,150 --> 01:01:35,599
contrast to that

1619
01:01:42,150 --> 01:01:40,160
the jwc near cam is those two tiny

1620
01:01:44,549 --> 01:01:42,160
uh that's the whole field of view of

1621
01:01:47,109 --> 01:01:44,559
near cam on jwst

1622
01:01:48,870 --> 01:01:47,119
um and that's actually bigger than the

1623
01:01:50,870 --> 01:01:48,880
field of view of hubble so it took a

1624
01:01:53,349 --> 01:01:50,880
tile of many many of these

1625
01:01:55,190 --> 01:01:53,359
uh to make the candles image and it

1626
01:01:57,109 --> 01:01:55,200
would take tiles of many many of these

1627
01:02:00,789 --> 01:01:57,119
to do similar surveys with

1628
01:02:02,390 --> 01:02:00,799
uh web vera rubin

1629
01:02:05,029 --> 01:02:02,400
observatory this big ground-based

1630
01:02:07,109 --> 01:02:05,039
telescope will have 3.2 billion pixels

1631
01:02:08,150 --> 01:02:07,119
will image the sky every 30 seconds for

1632
01:02:10,549 --> 01:02:08,160
10 years and

1633
01:02:12,470 --> 01:02:10,559
will have a catalog of about 20 billion

1634
01:02:16,230 --> 01:02:12,480
galaxies

1635
01:02:18,069 --> 01:02:16,240
um spatial resolution is another axis

1636
01:02:19,589 --> 01:02:18,079
and that's where you really want to get

1637
01:02:22,470 --> 01:02:19,599
into space or

1638
01:02:24,150 --> 01:02:22,480

and or have a very big mirror and if you

1639
01:02:24,549 --> 01:02:24,160
do it on the ground you have to invest

1640
01:02:26,549 --> 01:02:24,559
in

1641
01:02:28,390 --> 01:02:26,559
adaptive optics and try to take out the

1642
01:02:30,150 --> 01:02:28,400
atmosphere which is very very

1643
01:02:31,430 --> 01:02:30,160
challenging and won't be done with a

1644
01:02:33,910 --> 01:02:31,440
wide field of view

1645
01:02:35,349 --> 01:02:33,920
any time in our lifetime i don't think

1646
01:02:38,230 --> 01:02:35,359
um

1647
01:02:39,430 --> 01:02:38,240
so this is just a comparison of what a

1648
01:02:41,910 --> 01:02:39,440
typical image with

1649
01:02:43,910 --> 01:02:41,920
roman might look like compared to reuben

1650
01:02:47,349 --> 01:02:43,920
so you'll get much finer

1651
01:02:47,829 --> 01:02:47,359
detail of galaxies and stars and so on

1652
01:02:51,029 --> 01:02:47,839
uh

1653
01:02:51,990 --> 01:02:51,039
with the roman observatory this is a

1654
01:02:54,069 --> 01:02:52,000
comparison of

1655
01:02:55,270 --> 01:02:54,079
webb versus hubble which you could take

1656
01:02:57,430 --> 01:02:55,280
to be uh

1657
01:02:58,870 --> 01:02:57,440
webb versus roman because roman's very

1658
01:03:02,789 --> 01:02:58,880
similar to hubble and

1659
01:03:05,910 --> 01:03:02,799
resolution and so you can see jayrus t

1660
01:03:06,549 --> 01:03:05,920
or web um in the visible will have a

1661
01:03:08,950 --> 01:03:06,559
little bit

1662
01:03:10,630 --> 01:03:08,960
better resolution um but as you move

1663
01:03:13,910 --> 01:03:10,640

further to the infrared where it

1664
01:03:15,190 --> 01:03:13,920
its bigger mirror sort of gives it a big

1665
01:03:15,990 --> 01:03:15,200
advantage and you'll get better

1666
01:03:19,589 --> 01:03:16,000
resolution

1667
01:03:22,950 --> 01:03:19,599
it has a 0.03 arc second per pixel scale

1668
01:03:28,309 --> 01:03:22,960
compared to hubble which was 0.05 and

1669
01:03:32,789 --> 01:03:30,710
and then um the wavelength range the

1670
01:03:35,510 --> 01:03:32,799
spectral resolution and the sensitivity

1671
01:03:36,630 --> 01:03:35,520
are also extremely important attributes

1672
01:03:39,190 --> 01:03:36,640
of telescopes

1673
01:03:40,950 --> 01:03:39,200
and i'll try to summarize those on one

1674
01:03:43,510 --> 01:03:40,960
graph that compares these

1675
01:03:44,069 --> 01:03:43,520
different facilities so the euclid

1676
01:03:46,390 --> 01:03:44,079
satellite

1677
01:03:47,910 --> 01:03:46,400
which is a 1.3 meter telescope being

1678
01:03:51,029 --> 01:03:47,920
launched in 2022

1679
01:03:51,510 --> 01:03:51,039
by the european space agency uh also to

1680
01:03:54,870 --> 01:03:51,520
look

1681
01:03:57,349 --> 01:03:54,880
uh its big focus is to do kinds

1682
01:03:58,309 --> 01:03:57,359
the kinds of measurements on dark energy

1683
01:04:01,109 --> 01:03:58,319
that we're all hoping

1684
01:04:02,309 --> 01:04:01,119
all these facilities do so in particular

1685
01:04:05,589 --> 01:04:02,319
measure weak lensing

1686
01:04:09,109 --> 01:04:05,599
and clustering of galaxies

1687
01:04:11,990 --> 01:04:09,119
and it is

1688
01:04:14,549 --> 01:04:12,000

looking in particular or one of its

1689
01:04:17,910 --> 01:04:14,559
goals is to find emission line galaxies

1690
01:04:19,670 --> 01:04:17,920
uh with a spectrograph the spectrograph

1691
01:04:22,150 --> 01:04:19,680
while not as sensitive as these

1692
01:04:24,630 --> 01:04:22,160
imaging limits so its imaging limit is

1693
01:04:27,750 --> 01:04:24,640
about 24th magnitude which is

1694
01:04:29,750 --> 01:04:27,760
um it's uh

1695
01:04:30,950 --> 01:04:29,760
not you need a big telescope on the

1696
01:04:31,910 --> 01:04:30,960
ground to do that but it's not

1697
01:04:33,430 --> 01:04:31,920
particularly

1698
01:04:35,670 --> 01:04:33,440
challenging to do that from the ground

1699
01:04:37,510 --> 01:04:35,680
but you can't do that in the infrared

1700
01:04:38,789 --> 01:04:37,520
very easily over wide areas from the

1701
01:04:40,630 --> 01:04:38,799
ground

1702
01:04:42,630 --> 01:04:40,640
it then has a spectrograph that will be

1703
01:04:45,349 --> 01:04:42,640
able to see these emission lines

1704
01:04:46,710 --> 01:04:45,359
um with a a limiting magnitude that's

1705
01:04:48,870 --> 01:04:46,720
somewhat brighter but it the

1706
01:04:50,870 --> 01:04:48,880
emission lines still peak over that it

1707
01:04:52,470 --> 01:04:50,880
will survey a large fraction of this guy

1708
01:04:55,750 --> 01:04:52,480
sort of a third of the scar

1709
01:04:56,390 --> 01:04:55,760
sky or so the reuben telescope will

1710
01:04:59,750 --> 01:04:56,400
survey

1711
01:05:01,990 --> 01:04:59,760
about half the sky southern hemisphere

1712
01:05:03,029 --> 01:05:02,000
so it's a telescope in chile and will go

1713
01:05:05,910 --> 01:05:03,039

much much fainter

1714
01:05:06,309 --> 01:05:05,920
it's an imaging facility only so it goes

1715
01:05:08,630 --> 01:05:06,319
uh

1716
01:05:10,710 --> 01:05:08,640
very faint in imaging and it's an

1717
01:05:15,270 --> 01:05:10,720
optical facility only

1718
01:05:17,750 --> 01:05:15,280
sort of touching the near infrared um

1719
01:05:18,630 --> 01:05:17,760
roman is primarily a near-infrared

1720
01:05:20,150 --> 01:05:18,640
facility

1721
01:05:22,230 --> 01:05:20,160
that overlaps a little bit with the

1722
01:05:24,950 --> 01:05:22,240
reuben uh wavelengths

1723
01:05:26,470 --> 01:05:24,960
it can go deeper and it has a finer

1724
01:05:28,230 --> 01:05:26,480
resolution that we just saw

1725
01:05:30,789 --> 01:05:28,240
it won't cover nearly the area about a

1726
01:05:33,270 --> 01:05:30,799
tenth of the area over the mission

1727
01:05:35,270 --> 01:05:33,280
and then the web will cover a tiny

1728
01:05:36,150 --> 01:05:35,280
fraction of the area of any of these

1729
01:05:39,270 --> 01:05:36,160
surveys

1730
01:05:42,309 --> 01:05:39,280
but will go many magnitudes deeper

1731
01:05:44,549 --> 01:05:42,319
and so that that is really

1732
01:05:45,349 --> 01:05:44,559
what you need you'll be able to find for

1733
01:05:47,349 --> 01:05:45,359
example

1734
01:05:48,870 --> 01:05:47,359
redshift seven galaxies which is looking

1735
01:05:51,029 --> 01:05:48,880
back

1736
01:05:52,069 --> 01:05:51,039
more within a billion years at the big

1737
01:05:53,750 --> 01:05:52,079
bang

1738
01:05:55,990 --> 01:05:53,760

so very early galaxies you'll be able to

1739
01:05:58,870 --> 01:05:56,000
find the brighter ones with roman

1740
01:06:00,150 --> 01:05:58,880
and you can see the sort of signature of

1741
01:06:02,630 --> 01:06:00,160
their spectrum

1742
01:06:04,150 --> 01:06:02,640
uh in the colors of the roman filters

1743
01:06:05,589 --> 01:06:04,160
but you'll really be able to study them

1744
01:06:06,789 --> 01:06:05,599
and measure their shapes and measure the

1745
01:06:08,230 --> 01:06:06,799
fainter ones

1746
01:06:10,230 --> 01:06:08,240
with the webb telescope and find the

1747
01:06:12,309 --> 01:06:10,240
more distant ones

1748
01:06:13,990 --> 01:06:12,319
so just to sort of summarize the science

1749
01:06:15,430 --> 01:06:14,000
trades and i haven't gone through all of

1750
01:06:18,950 --> 01:06:15,440
them so you have the field of view the

1751
01:06:22,390 --> 01:06:18,960
spectral resolution the wavelength range

1752
01:06:24,150 --> 01:06:22,400
sensitivity i didn't talk about contrast

1753
01:06:26,470 --> 01:06:24,160
jason talked about that a bit in his

1754
01:06:29,430 --> 01:06:26,480
talk on the um

1755
01:06:31,270 --> 01:06:29,440
the coronagraph and then we talked a

1756
01:06:33,430 --> 01:06:31,280
little bit about the time domain

1757
01:06:35,349 --> 01:06:33,440
agility and it so if you just go back to

1758
01:06:37,829 --> 01:06:35,359
those decadal themes

1759
01:06:38,710 --> 01:06:37,839
uh you sort of need to emphasize field

1760
01:06:40,549 --> 01:06:38,720
of view spatial

1761
01:06:42,950 --> 01:06:40,559
spatial resolution wavelength range and

1762
01:06:44,710 --> 01:06:42,960
sensitivity uh to be studying

1763
01:06:47,589 --> 01:06:44,720

uh the dark energy and the physics of

1764
01:06:48,150 --> 01:06:47,599
the universe the cosmic dawn emphasizes

1765
01:06:51,349 --> 01:06:48,160
the

1766
01:06:54,069 --> 01:06:51,359
and sensitivity

1767
01:06:56,069 --> 01:06:54,079
planetary systems really need everything

1768
01:06:58,230 --> 01:06:56,079
uh because the planets are faint

1769
01:06:59,430 --> 01:06:58,240
uh but the stars around them are bright

1770
01:07:02,230 --> 01:06:59,440
um and you need

1771
01:07:04,309 --> 01:07:02,240
um to look at it over time and you need

1772
01:07:06,870 --> 01:07:04,319
a wide field of view for some of the

1773
01:07:08,309 --> 01:07:06,880
planet finding uh techniques like

1774
01:07:11,190 --> 01:07:08,319
microlensing

1775
01:07:12,230 --> 01:07:11,200
um and then time domain uh needs uh

1776
01:07:14,710 --> 01:07:12,240
field of view

1777
01:07:15,910 --> 01:07:14,720
wavelength range sensitivity and some

1778
01:07:19,109 --> 01:07:15,920
ability which

1779
01:07:20,630 --> 01:07:19,119
uh means the ability to visit fields

1780
01:07:24,710 --> 01:07:20,640
many times

1781
01:07:27,589 --> 01:07:24,720
uh observe fairly rapidly uh it also

1782
01:07:28,069 --> 01:07:27,599
for some science means the ability to

1783
01:07:31,349 --> 01:07:28,079
react

1784
01:07:33,190 --> 01:07:31,359
rapidly which is a real challenge in in

1785
01:07:36,390 --> 01:07:33,200
many facilities to do that

1786
01:07:38,069 --> 01:07:36,400
so one example in the time domain

1787
01:07:40,390 --> 01:07:38,079
which is particularly exciting right now

1788
01:07:41,430 --> 01:07:40,400

is ligo is discovering gravitational

1789
01:07:42,789 --> 01:07:41,440
wave events

1790
01:07:44,630 --> 01:07:42,799
now you actually might be able to

1791
01:07:45,029 --> 01:07:44,640
discover those with a wide field survey

1792
01:07:47,910 --> 01:07:45,039
like

1793
01:07:48,549 --> 01:07:47,920
lsst in the electromagnetic spectrum

1794
01:07:50,630 --> 01:07:48,559
before

1795
01:07:52,549 --> 01:07:50,640
or at the same time as a gravitational

1796
01:07:54,390 --> 01:07:52,559
wave observatory finds them

1797
01:07:56,150 --> 01:07:54,400
but you need a very wide field to have a

1798
01:07:58,870 --> 01:07:56,160
hope to do that um

1799
01:07:59,910 --> 01:07:58,880
but um in the current scenarios ligo

1800
01:08:02,710 --> 01:07:59,920
detects it

1801
01:08:03,990 --> 01:08:02,720
you then try to localize it and ligos

1802
01:08:07,109 --> 01:08:04,000
and virgo together

1803
01:08:10,230 --> 01:08:07,119
virgo's an italian gravitational wave

1804
01:08:10,630 --> 01:08:10,240
detector can localize it to a an area

1805
01:08:12,789 --> 01:08:10,640
that's

1806
01:08:14,150 --> 01:08:12,799
actually still much larger than the lsst

1807
01:08:15,109 --> 01:08:14,160
field of view so you need some other

1808
01:08:18,070 --> 01:08:15,119
facilities

1809
01:08:18,709 --> 01:08:18,080
to localize to small enough that lsst

1810
01:08:20,709 --> 01:08:18,719
can find

1811
01:08:23,430 --> 01:08:20,719
something that may look a little bit

1812
01:08:25,669 --> 01:08:23,440
different and in any field there may be

1813
01:08:27,910 --> 01:08:25,679

many hundreds of those so you need to

1814
01:08:30,390 --> 01:08:27,920
figure out which one it was

1815
01:08:32,070 --> 01:08:30,400
and then if you can do that webb and

1816
01:08:34,630 --> 01:08:32,080
roman can localize it even further

1817
01:08:38,070 --> 01:08:34,640
within the galaxy and measure it over

1818
01:08:40,470 --> 01:08:38,080
months and weeks and months

1819
01:08:41,829 --> 01:08:40,480
uh so just to to bring back to the

1820
01:08:44,149 --> 01:08:41,839
beginning uh there are

1821
01:08:45,590 --> 01:08:44,159
exciting times to come within a few

1822
01:08:47,349 --> 01:08:45,600
years we're going to have these

1823
01:08:50,630 --> 01:08:47,359
revolutionary facilities

1824
01:08:53,749 --> 01:08:50,640
uh operating uh all at the same time

1825
01:08:55,189 --> 01:08:53,759
and astronomy's just going to continue

1826
01:08:58,229 --> 01:08:55,199
the revolution that was

1827
01:09:02,870 --> 01:08:58,239
begun by all the previous telescopes

1828
01:09:06,470 --> 01:09:05,349
thank you harry we're all very excited

1829
01:09:10,309 --> 01:09:06,480
to see what the

1830
01:09:16,229 --> 01:09:13,510
all right so um for those of you

1831
01:09:25,269 --> 01:09:16,239
watching this live event um i encourage

1832
01:09:28,390 --> 01:09:27,829
that have already come in so um grant is

1833
01:09:30,870 --> 01:09:28,400
going to

1834
01:09:32,070 --> 01:09:30,880
work us through those i encourage all of

1835
01:09:34,390 --> 01:09:32,080
our speakers to

1836
01:09:35,749 --> 01:09:34,400
turn on their videos um so that people

1837
01:09:38,309 --> 01:09:35,759
can see you as you're responding to the

1838
01:09:45,110 --> 01:09:41,749

so grant do you want to kick us off

1839
01:09:46,950 --> 01:09:45,120
yeah absolutely um so

1840
01:09:48,309 --> 01:09:46,960
thank you everyone for joining i

1841
01:09:50,309 --> 01:09:48,319
apologize again for

1842
01:09:51,430 --> 01:09:50,319
our slightly later start than we

1843
01:09:54,470 --> 01:09:51,440
expected

1844
01:09:57,590 --> 01:09:54,480
but uh the first one is for dr lupier

1845
01:10:00,950 --> 01:09:57,600
what was the subject of ngr's 1950

1846
01:10:03,990 --> 01:10:00,960
top 100 apj paper

1847
01:10:05,030 --> 01:10:04,000
yes uh nancy grace roman uh was

1848
01:10:08,709 --> 01:10:05,040
measuring

1849
01:10:10,709 --> 01:10:08,719
uh uh stars star similar to the sun

1850
01:10:12,790 --> 01:10:10,719
and uh she was using spectral

1851
01:10:13,669 --> 01:10:12,800
classification that that her thesis

1852
01:10:16,630 --> 01:10:13,679
advisor

1853
01:10:17,270 --> 01:10:16,640
and others had defined and and what she

1854
01:10:20,950 --> 01:10:17,280
found

1855
01:10:23,990 --> 01:10:20,960
was that these stars that had

1856
01:10:25,830 --> 01:10:24,000
um components heavier than hydrogen we

1857
01:10:28,310 --> 01:10:25,840
call them metal lines

1858
01:10:30,390 --> 01:10:28,320
metal line stars anything heavier than

1859
01:10:34,790 --> 01:10:30,400
than hydrogen uh

1860
01:10:37,990 --> 01:10:34,800
stars with the with metal lines had uh

1861
01:10:41,510 --> 01:10:38,000
had velocities that spanned

1862
01:10:43,910 --> 01:10:41,520
a large range and uh these

1863
01:10:44,870 --> 01:10:43,920

metal line stars had velocity range

1864
01:10:47,270 --> 01:10:44,880
where they were

1865
01:10:48,630 --> 01:10:47,280
some of the velocities were faster than

1866
01:10:51,830 --> 01:10:48,640
you know 70

1867
01:10:54,950 --> 01:10:51,840
uh 70 kilometers

1868
01:10:57,990 --> 01:10:54,960
per second and the

1869
01:10:59,510 --> 01:10:58,000
non-metal line stars also had a range of

1870
01:11:02,550 --> 01:10:59,520
velocity but not

1871
01:11:03,990 --> 01:11:02,560
any not the very fast speeds so these

1872
01:11:05,830 --> 01:11:04,000
stars were not

1873
01:11:08,070 --> 01:11:05,840
moving at very fast speeds so that was

1874
01:11:10,950 --> 01:11:08,080
able that

1875
01:11:11,510 --> 01:11:10,960
that she was able to tell something

1876
01:11:13,750 --> 01:11:11,520
about

1877
01:11:15,110 --> 01:11:13,760
um you know the difference between the

1878
01:11:17,910 --> 01:11:15,120
two sets of stars

1879
01:11:19,189 --> 01:11:17,920
and uh learn something about you know

1880
01:11:21,189 --> 01:11:19,199
the first

1881
01:11:22,310 --> 01:11:21,199
pieces of information about galactic

1882
01:11:24,709 --> 01:11:22,320
structure

1883
01:11:26,149 --> 01:11:24,719
uh because she found found these metal

1884
01:11:32,550 --> 01:11:26,159
line stars

1885
01:11:33,669 --> 01:11:32,560
and redder and um moving in more

1886
01:11:36,630 --> 01:11:33,679
elliptical orbits

1887
01:11:37,990 --> 01:11:36,640
whereas the you know the stars with more

1888
01:11:40,149 --> 01:11:38,000

metal lines were younger

1889
01:11:46,070 --> 01:11:40,159
and they were more they tended more to

1890
01:11:53,510 --> 01:11:50,470
awesome thank you and so the next step

1891
01:11:53,990 --> 01:11:53,520
is a question for dr mcheanery you

1892
01:11:56,149 --> 01:11:54,000
mentioned

1893
01:11:57,189 --> 01:11:56,159
that roman's observations will be more

1894
01:11:59,189 --> 01:11:57,199
efficient

1895
01:12:00,709 --> 01:11:59,199
than hubble's but how much more

1896
01:12:02,630 --> 01:12:00,719
sensitive if at all

1897
01:12:04,470 --> 01:12:02,640
are roman's imaging detectors versus

1898
01:12:05,750 --> 01:12:04,480
hubble's

1899
01:12:09,270 --> 01:12:05,760
actually something we talked about in

1900
01:12:12,790 --> 01:12:09,280
our setup for this

1901
01:12:14,390 --> 01:12:12,800
um so the um our actual uh detectors

1902
01:12:17,430 --> 01:12:14,400
themselves um

1903
01:12:20,070 --> 01:12:17,440
are a little bit more um uh

1904
01:12:22,310 --> 01:12:20,080
more sensitive than uh than hubble's um

1905
01:12:25,430 --> 01:12:22,320
and they extend um

1906
01:12:28,229 --> 01:12:25,440
the sensitivity extends out to slightly

1907
01:12:29,030 --> 01:12:28,239
redder uh redder wavelengths but it's

1908
01:12:38,550 --> 01:12:29,040
not um

1909
01:12:41,590 --> 01:12:40,229
if there are any further points that you

1910
01:12:43,669 --> 01:12:41,600
want to make or

1911
01:12:45,590 --> 01:12:43,679
that you would like us to answer please

1912
01:12:48,790 --> 01:12:45,600
put them in the chat i'm going to go

1913
01:12:49,430 --> 01:12:48,800

question by question um all right so

1914
01:12:51,910 --> 01:12:49,440
next up

1915
01:12:53,590 --> 01:12:51,920
from aas press office uh what is the

1916
01:12:59,030 --> 01:12:53,600
reference target guide star for the

1917
01:13:05,110 --> 01:13:02,229
uh so the coronagraph uh we have not

1918
01:13:08,709 --> 01:13:05,120
identified a set of target lists

1919
01:13:11,030 --> 01:13:08,719
yet we're working on that uh in part

1920
01:13:13,110 --> 01:13:11,040
it's because the set of target lists

1921
01:13:13,590 --> 01:13:13,120
will depend on exactly when we launch

1922
01:13:15,910 --> 01:13:13,600
and

1923
01:13:17,270 --> 01:13:15,920
exactly when the coronagraph

1924
01:13:19,990 --> 01:13:17,280
[Music]

1925
01:13:21,110 --> 01:13:20,000
will be undergoing its its technology

1926
01:13:23,430 --> 01:13:21,120
demonstration

1927
01:13:25,830 --> 01:13:23,440
so what we're doing is we're identifying

1928
01:13:28,870 --> 01:13:25,840
all the possible targets that we could

1929
01:13:29,590 --> 01:13:28,880
uh hit and there's a few dozen and for

1930
01:13:32,790 --> 01:13:29,600
each of those

1931
01:13:33,350 --> 01:13:32,800
there will be uh a nearby star that we

1932
01:13:36,790 --> 01:13:33,360
use

1933
01:13:37,430 --> 01:13:36,800
uh to uh what we call dig the dark hole

1934
01:13:39,510 --> 01:13:37,440
that is

1935
01:13:40,790 --> 01:13:39,520
make the dark hole around the star and

1936
01:13:43,830 --> 01:13:40,800
then we go to the

1937
01:13:44,790 --> 01:13:43,840
actual coronagraph uh target uh which

1938
01:13:47,189 --> 01:13:44,800

has the planet

1939
01:13:48,070 --> 01:13:47,199
and we use that uh dark hole that we've

1940
01:13:52,950 --> 01:13:48,080
dug

1941
01:13:59,430 --> 01:13:56,390
thank you all right so

1942
01:14:02,149 --> 01:13:59,440
uh question for dr reese how do

1943
01:14:04,630 --> 01:14:02,159
uh how does the uh the roman dark energy

1944
01:14:06,950 --> 01:14:04,640
survey compare with or expand upon

1945
01:14:09,990 --> 01:14:06,960
current dark energy surveys such as

1946
01:14:13,189 --> 01:14:10,000
des head decks etc

1947
01:14:15,990 --> 01:14:13,199
right um well it will have more

1948
01:14:17,830 --> 01:14:16,000
area than those for the kind of weak

1949
01:14:20,550 --> 01:14:17,840
lensing measurements um

1950
01:14:21,830 --> 01:14:20,560
it will go to higher redshifts than the

1951
01:14:25,030 --> 01:14:21,840
various supernova

1952
01:14:26,390 --> 01:14:25,040
projects um it will get a greater

1953
01:14:29,270 --> 01:14:26,400
density of galaxies

1954
01:14:29,990 --> 01:14:29,280
than the baryon acoustic oscillation

1955
01:14:33,669 --> 01:14:30,000
surveys

1956
01:14:35,430 --> 01:14:33,679
um and so we typically quantify

1957
01:14:37,270 --> 01:14:35,440
uh how good the dark energy constraints

1958
01:14:38,390 --> 01:14:37,280
will be as a what we call a figure of

1959
01:14:41,189 --> 01:14:38,400
merit which is

1960
01:14:42,229 --> 01:14:41,199
uh really the inverse of the uncertainty

1961
01:14:45,590 --> 01:14:42,239
and in that

1962
01:14:47,669 --> 01:14:45,600
measure um uh roman

1963
01:14:50,070 --> 01:14:47,679

should be a factor of 10 better than

1964
01:14:51,830 --> 01:14:50,080
anything we previously knew which

1965
01:14:53,350 --> 01:14:51,840
um you know one way of thinking about

1966
01:14:57,189 --> 01:14:53,360
that is uh

1967
01:14:58,950 --> 01:14:57,199
if uh it's just fortuitous that right

1968
01:15:00,470 --> 01:14:58,960
now dark energy looks kind of like a

1969
01:15:02,790 --> 01:15:00,480
cosmodrome constant

1970
01:15:04,470 --> 01:15:02,800
then we should have a 90 chance of

1971
01:15:07,750 --> 01:15:04,480
finding an answer

1972
01:15:10,709 --> 01:15:07,760
uh that uh allows us to separate

1973
01:15:12,149 --> 01:15:10,719
uh reality from that value if uh in fact

1974
01:15:13,110 --> 01:15:12,159
the right answer is a cosmological

1975
01:15:14,550 --> 01:15:13,120
constant then

1976
01:15:16,630 --> 01:15:14,560
every time we go back and measure a

1977
01:15:17,510 --> 01:15:16,640
factor of 10 better we'll keep getting

1978
01:15:24,149 --> 01:15:17,520
the same answer

1979
01:15:27,830 --> 01:15:24,159
and at some point we'll get tired

1980
01:15:29,910 --> 01:15:27,840
wonderful answer all right so

1981
01:15:31,590 --> 01:15:29,920
uh it seems like the great advantage of

1982
01:15:33,669 --> 01:15:31,600
ngr is in its power to

1983
01:15:35,030 --> 01:15:33,679
deliver statistics larger numbers of

1984
01:15:37,990 --> 01:15:35,040
events greater areas

1985
01:15:38,950 --> 01:15:38,000
deep deaths in shorter times larger time

1986
01:15:40,870 --> 01:15:38,960
scales

1987
01:15:42,149 --> 01:15:40,880
what is the fundamental discovery

1988
01:15:44,070 --> 01:15:42,159

potential

1989
01:15:45,510 --> 01:15:44,080
are there regimes of the universe that

1990
01:15:46,149 --> 01:15:45,520
it will be able to observe for the first

1991
01:15:48,229 --> 01:15:46,159
time

1992
01:15:49,350 --> 01:15:48,239
that uh no other observatory i'm going

1993
01:15:51,030 --> 01:15:49,360
to assume that was supposed to be

1994
01:15:53,110 --> 01:15:51,040
regions

1995
01:15:57,350 --> 01:15:53,120
that no other observatory hitherto has

1996
01:16:00,229 --> 01:15:58,630
i'll kind of float that one up and

1997
01:16:03,750 --> 01:16:00,239
whoever would like to take that can take

1998
01:16:10,790 --> 01:16:07,510
i can take a first stab at that

1999
01:16:13,910 --> 01:16:13,430
because roman will be able to simply

2000
01:16:16,149 --> 01:16:13,920
survey

2001
01:16:18,709 --> 01:16:16,159
much larger areas that means that we'll

2002
01:16:20,709 --> 01:16:18,719
get a sample of more diversity

2003
01:16:22,709 --> 01:16:20,719
right more diverse kinds of environments

2004
01:16:26,390 --> 01:16:22,719
more diverse kinds of objects

2005
01:16:29,030 --> 01:16:26,400
so for example with hubble there just

2006
01:16:31,510 --> 01:16:29,040
weren't enough orbits to you know

2007
01:16:32,310 --> 01:16:31,520
necessarily get those diverse samples

2008
01:16:34,229 --> 01:16:32,320
and so

2009
01:16:36,550 --> 01:16:34,239
you know we may discover things that

2010
01:16:38,310 --> 01:16:36,560
surprise us because they're very rare

2011
01:16:39,750 --> 01:16:38,320
and we weren't lucky enough to see them

2012
01:16:41,510 --> 01:16:39,760
before and of course we don't know what

2013
01:16:43,590 --> 01:16:41,520

those might be

2014
01:16:45,590 --> 01:16:43,600
one example that i mentioned is these

2015
01:16:46,790 --> 01:16:45,600
very massive black holes that we see at

2016
01:16:49,910 --> 01:16:46,800
early times

2017
01:16:51,350 --> 01:16:49,920
so you know we know that those exist but

2018
01:16:54,390 --> 01:16:51,360
we don't know very much

2019
01:16:55,030 --> 01:16:54,400
about um for example the black holes

2020
01:16:57,110 --> 01:16:55,040
that are

2021
01:16:58,070 --> 01:16:57,120
accreting just a little bit less rapidly

2022
01:17:03,430 --> 01:16:58,080
or a little bit

2023
01:17:05,510 --> 01:17:03,440
fainter so that that's an example

2024
01:17:07,110 --> 01:17:05,520
yeah i could uh comment on this as well

2025
01:17:09,270 --> 01:17:07,120
i find um

2026
01:17:11,189 --> 01:17:09,280
uh i mean it's a very difficult question

2027
01:17:13,350 --> 01:17:11,199
to answer because you're asking us

2028
01:17:14,550 --> 01:17:13,360
to uh we're being asked to sort of uh

2029
01:17:17,430 --> 01:17:14,560
hypothesize on

2030
01:17:18,390 --> 01:17:17,440
uh on the unknown but what really

2031
01:17:21,669 --> 01:17:18,400
excites me

2032
01:17:23,830 --> 01:17:21,679
um about uh roman is that we're

2033
01:17:25,189 --> 01:17:23,840
going to find things without looking for

2034
01:17:27,110 --> 01:17:25,199
them in the sense that the kind of

2035
01:17:28,950 --> 01:17:27,120
obstacles that we make

2036
01:17:30,390 --> 01:17:28,960
aren't i think there's an interesting

2037
01:17:32,070 --> 01:17:30,400
galaxy here and i'm going to point there

2038
01:17:33,669 --> 01:17:32,080

and make observations of that galaxy and

2039
01:17:36,550 --> 01:17:33,679
i might or there might not be something

2040
01:17:38,630 --> 01:17:36,560
um interesting there we're going to you

2041
01:17:40,630 --> 01:17:38,640
know for example have a two degree

2042
01:17:41,990 --> 01:17:40,640
region towards the galactic center that

2043
01:17:42,709 --> 01:17:42,000
we're going to go back to every 15

2044
01:17:45,669 --> 01:17:42,719
minutes

2045
01:17:46,870 --> 01:17:45,679
and while we know that that set of

2046
01:17:49,590 --> 01:17:46,880
observations are

2047
01:17:50,630 --> 01:17:49,600
going to net us a large hall of

2048
01:17:52,550 --> 01:17:50,640
exoplanets

2049
01:17:53,669 --> 01:17:52,560
that same set of observations are also

2050
01:17:56,709 --> 01:17:53,679
going to provide us

2051
01:17:58,630 --> 01:17:56,719
exquisite um measurements of the of the

2052
01:18:02,070 --> 01:17:58,640
motions of the stars uh there

2053
01:18:04,550 --> 01:18:02,080
they're going to um allow us

2054
01:18:06,310 --> 01:18:04,560
to find other things that are causing

2055
01:18:07,110 --> 01:18:06,320
this gravitational microlensing so we're

2056
01:18:10,390 --> 01:18:07,120
going to

2057
01:18:12,470 --> 01:18:10,400
measure um populations of um

2058
01:18:13,990 --> 01:18:12,480
of neutron stars that might be wandering

2059
01:18:14,709 --> 01:18:14,000
around our galaxy we've got the

2060
01:18:16,550 --> 01:18:14,719
potential

2061
01:18:18,229 --> 01:18:16,560
with those same observations to maybe

2062
01:18:21,350 --> 01:18:18,239
identify small

2063
01:18:23,990 --> 01:18:21,360

clumps of of of dark matter

2064
01:18:24,709 --> 01:18:24,000
um to some extent the phase space that

2065
01:18:27,830 --> 01:18:24,719
we open

2066
01:18:28,630 --> 01:18:27,840
with roman is going to be a function of

2067
01:18:31,750 --> 01:18:28,640
how we

2068
01:18:33,990 --> 01:18:31,760
think when you have

2069
01:18:35,510 --> 01:18:34,000
uh an observatory with this sensitivity

2070
01:18:37,189 --> 01:18:35,520
and this field of view

2071
01:18:39,590 --> 01:18:37,199
there are many different ways that we

2072
01:18:41,669 --> 01:18:39,600
can make observations that will open you

2073
01:18:43,110 --> 01:18:41,679
face space and one of the things that

2074
01:18:45,669 --> 01:18:43,120
we're looking forward to doing

2075
01:18:47,430 --> 01:18:45,679
over the next few years is working with

2076
01:18:49,910 --> 01:18:47,440
the community to try and identify

2077
01:18:52,149 --> 01:18:49,920
what are those ways that we can make

2078
01:18:55,189 --> 01:18:52,159
groundbreaking observations that

2079
01:18:58,790 --> 01:18:55,199
openness provide an opportunity for

2080
01:19:00,870 --> 01:18:58,800
the greatest number of new discoveries

2081
01:19:02,950 --> 01:19:00,880
i just wanted to uh amplify that point

2082
01:19:05,990 --> 01:19:02,960
as well that i think we're entering

2083
01:19:07,990 --> 01:19:06,000
a kind of new paradigm of uh sort of

2084
01:19:09,990 --> 01:19:08,000
astronomical instant gratification

2085
01:19:11,510 --> 01:19:10,000
you used to see something interesting

2086
01:19:12,709 --> 01:19:11,520
you know a few objects

2087
01:19:14,390 --> 01:19:12,719
and you'd say oh that's kind of

2088
01:19:15,990 --> 01:19:14,400

interesting i'm not sure if it's true

2089
01:19:17,669 --> 01:19:16,000
i'll write an observing proposal to get

2090
01:19:18,550 --> 01:19:17,679
more time to look at more of those

2091
01:19:20,390 --> 01:19:18,560
objects

2092
01:19:21,990 --> 01:19:20,400
and now whenever you see something

2093
01:19:24,149 --> 01:19:22,000
interesting you're going to be able to

2094
01:19:25,590 --> 01:19:24,159
immediately sort of download these

2095
01:19:27,189 --> 01:19:25,600
massive data sets where you can

2096
01:19:29,430 --> 01:19:27,199
basically see everything

2097
01:19:31,030 --> 01:19:29,440
and follow up on any interesting signal

2098
01:19:32,550 --> 01:19:31,040
that you see so

2099
01:19:33,830 --> 01:19:32,560
you know to me it's very exciting as a

2100
01:19:35,990 --> 01:19:33,840
scientist that we're going to be able to

2101
01:19:40,790 --> 01:19:36,000
dive right into everything you see you

2102
01:19:44,709 --> 01:19:43,510
beautiful thank you and just like

2103
01:19:47,189 --> 01:19:44,719
anything else

2104
01:19:48,950 --> 01:19:47,199
we're only as good as our sample size

2105
01:19:51,990 --> 01:19:48,960
we'll be getting it without realizing it

2106
01:19:55,270 --> 01:19:52,000
or intending to in the surrounding areas

2107
01:19:57,669 --> 01:19:55,280
all right so do the tens of thousands of

2108
01:19:58,070 --> 01:19:57,679
supernovae that the ngr telescope will

2109
01:20:00,790 --> 01:19:58,080
measure

2110
01:20:02,390 --> 01:20:00,800
include all types of supernovae or just

2111
01:20:04,390 --> 01:20:02,400
the relevant types

2112
01:20:05,990 --> 01:20:04,400
that we can use as a standard

2113
01:20:09,030 --> 01:20:06,000

cosmological candles

2114
01:20:10,870 --> 01:20:09,040
how many snla um

2115
01:20:12,390 --> 01:20:10,880
i i guess i'll i'll take a first swing

2116
01:20:14,629 --> 01:20:12,400
at this um we

2117
01:20:16,950 --> 01:20:14,639
will certainly uh observe all types of

2118
01:20:19,990 --> 01:20:16,960
supernovae the observatory is really

2119
01:20:22,470 --> 01:20:20,000
designed and really spec'd to do

2120
01:20:23,590 --> 01:20:22,480
an outstanding job on the type 1a

2121
01:20:25,350 --> 01:20:23,600
supernovae but

2122
01:20:26,950 --> 01:20:25,360
along the way we will find a core

2123
01:20:28,709 --> 01:20:26,960
collapsed supernovae

2124
01:20:30,310 --> 01:20:28,719
stars that fall directly into black

2125
01:20:31,750 --> 01:20:30,320
holes

2126
01:20:33,430 --> 01:20:31,760
if we're lucky we'll find some of these

2127
01:20:35,030 --> 01:20:33,440
parent stability supernovae

2128
01:20:37,510 --> 01:20:35,040
uh we'll be able to see supernovae at

2129
01:20:38,950 --> 01:20:37,520
greater redshifts uh which means earlier

2130
01:20:40,390 --> 01:20:38,960
back in time so

2131
01:20:42,229 --> 01:20:40,400
if we're lucky we will see some of the

2132
01:20:45,350 --> 01:20:42,239
very first supernovae

2133
01:20:46,149 --> 01:20:45,360
so-called uh supernovae that occur after

2134
01:20:48,390 --> 01:20:46,159
population

2135
01:20:50,310 --> 01:20:48,400
three stars which is uh the first

2136
01:20:51,030 --> 01:20:50,320
mythical but sort of first generation of

2137
01:20:53,350 --> 01:20:51,040
stars

2138
01:20:54,229 --> 01:20:53,360

and so we will see all types and there

2139
01:20:56,470 --> 01:20:54,239
should be enough

2140
01:20:57,669 --> 01:20:56,480
discriminating power on the observatory

2141
01:20:59,750 --> 01:20:57,679
to let us know that we are

2142
01:21:04,470 --> 01:20:59,760
indeed seeing a different type maybe

2143
01:21:10,790 --> 01:21:07,830
and i could add a little to that um that

2144
01:21:11,990 --> 01:21:10,800
the precise number of uh supernovanes

2145
01:21:14,870 --> 01:21:12,000
that we detect is

2146
01:21:17,189 --> 01:21:14,880
a a function of how we choose to take

2147
01:21:19,430 --> 01:21:17,199
the observations and we have a choice

2148
01:21:21,510 --> 01:21:19,440
between um a set of observations that

2149
01:21:24,310 --> 01:21:21,520
would know a large number of supernova

2150
01:21:26,629 --> 01:21:24,320
versus a smaller number of slightly

2151
01:21:29,590 --> 01:21:26,639
better characterized uh ones

2152
01:21:30,550 --> 01:21:29,600
um so the uh expected range of what we

2153
01:21:33,270 --> 01:21:30,560
might expect to see

2154
01:21:35,110 --> 01:21:33,280
is anywhere from a few thousand to

2155
01:21:36,629 --> 01:21:35,120
approaching twenty thousand

2156
01:21:39,030 --> 01:21:36,639
just depending on on how the

2157
01:21:43,990 --> 01:21:39,040
observations themselves are are made

2158
01:21:48,390 --> 01:21:46,709
thank you everyone um all right so it

2159
01:21:51,030 --> 01:21:48,400
looks like we have

2160
01:21:52,709 --> 01:21:51,040
another one from double aas uh question

2161
01:21:54,550 --> 01:21:52,719
for dr ferguson

2162
01:21:56,310 --> 01:21:54,560
when is roman expected to launch and how

2163
01:22:01,189 --> 01:21:56,320

much overlap in time

2164
01:22:05,350 --> 01:22:02,870
so we're hoping for somewhere around

2165
01:22:08,390 --> 01:22:05,360
2025

2166
01:22:11,830 --> 01:22:08,400
everything's uncertain these days so

2167
01:22:15,430 --> 01:22:11,840
stay tuned um the uh

2168
01:22:19,030 --> 01:22:15,440
reuben observatory is uh going online

2169
01:22:22,550 --> 01:22:19,040
hopefully in uh well actually probably

2170
01:22:26,070 --> 01:22:22,560
2021 uh with a smaller camera and then

2171
01:22:27,350 --> 01:22:26,080
the larger camera in 2022 um and as they

2172
01:22:30,470 --> 01:22:27,360
were waiting for webb

2173
01:22:33,270 --> 01:22:30,480
uh it's it is uh

2174
01:22:35,750 --> 01:22:33,280
i think i don't know i don't recall if

2175
01:22:36,149 --> 01:22:35,760
it's still officially october of 2021

2176
01:22:39,270 --> 01:22:36,159
but

2177
01:22:42,709 --> 01:22:39,280
uh 2021 2022 uh

2178
01:22:49,270 --> 01:22:42,719
depending on how things clear up um

2179
01:22:55,510 --> 01:22:53,430
okay and then they um um

2180
01:22:56,629 --> 01:22:55,520
the the lifetime of the missions of

2181
01:22:59,350 --> 01:22:56,639
course

2182
01:23:00,870 --> 01:22:59,360
the space mission you typically uh have

2183
01:23:04,070 --> 01:23:00,880
a five-year

2184
01:23:07,030 --> 01:23:04,080
maine life so webbin and uh

2185
01:23:08,229 --> 01:23:07,040
and roman are both nominally five years

2186
01:23:10,870 --> 01:23:08,239
and hopefully they will

2187
01:23:12,390 --> 01:23:10,880
outlast that uh and we'll get much

2188
01:23:16,470 --> 01:23:12,400

longer observing

2189
01:23:17,590 --> 01:23:16,480
times okay

2190
01:23:19,590 --> 01:23:17,600
i have a follow-up to one of the

2191
01:23:21,910 --> 01:23:19,600
previous questions

2192
01:23:23,270 --> 01:23:21,920
if the reference target that we use also

2193
01:23:28,790 --> 01:23:23,280
has planets

2194
01:23:32,390 --> 01:23:31,750
ah that's a that's a great question so

2195
01:23:36,149 --> 01:23:32,400
uh

2196
01:23:39,430 --> 01:23:36,159
targets that have

2197
01:23:41,590 --> 01:23:39,440
uh that we've already observed before

2198
01:23:42,550 --> 01:23:41,600
and have planets that are uh small

2199
01:23:45,669 --> 01:23:42,560
enough that they wouldn't

2200
01:23:48,390 --> 01:23:45,679
uh affect that uh so we have

2201
01:23:49,830 --> 01:23:48,400
uh coronagraphs on the ground and we

2202
01:23:51,030 --> 01:23:49,840
have a coronagraph

2203
01:23:53,110 --> 01:23:51,040
on the hubble and there will be a

2204
01:23:54,470 --> 01:23:53,120
chronograph on the james webb and so

2205
01:23:57,669 --> 01:23:54,480
we're not going to choose

2206
01:24:00,830 --> 01:23:57,679
uh um stars that we haven't uh

2207
01:24:02,629 --> 01:24:00,840
observed before to use with our our

2208
01:24:04,310 --> 01:24:02,639
coronagraph

2209
01:24:05,910 --> 01:24:04,320
in the initial uh technology

2210
01:24:08,550 --> 01:24:05,920
demonstration we may

2211
01:24:09,350 --> 01:24:08,560
uh if we use it beyond that we may go

2212
01:24:11,430 --> 01:24:09,360
searching

2213
01:24:12,790 --> 01:24:11,440

uh for stars that we don't know if they

2214
01:24:14,830 --> 01:24:12,800
have planets but in the initial

2215
01:24:20,870 --> 01:24:14,840
technology demonstration we'll make sure

2216
01:24:24,629 --> 01:24:23,830
sounds good um i don't see any further

2217
01:24:27,910 --> 01:24:24,639
questions

2218
01:24:31,590 --> 01:24:29,669
you might you mind if i jump in with a

2219
01:24:35,030 --> 01:24:31,600
couple of quick questions

2220
01:24:36,790 --> 01:24:35,040
go for it okay uh thank you um

2221
01:24:38,790 --> 01:24:36,800
so my first question is for uh dr

2222
01:24:41,669 --> 01:24:38,800
ferguson and i was wondering

2223
01:24:43,910 --> 01:24:41,679
um in the section on the key science

2224
01:24:45,830 --> 01:24:43,920
themes and specifically cosmic dawn

2225
01:24:47,430 --> 01:24:45,840
you mentioned looking at emission and

2226
01:24:49,430 --> 01:24:47,440
absorption lines

2227
01:24:51,350 --> 01:24:49,440
uh does roman have spectroscopic

2228
01:24:53,669 --> 01:24:51,360
capabilities too or will it

2229
01:24:55,189 --> 01:24:53,679
be more identifying targets for these

2230
01:24:56,790 --> 01:24:55,199
other observatories you were talking

2231
01:25:00,070 --> 01:24:56,800
about to study

2232
01:25:01,189 --> 01:25:00,080
so roman has a spectroscopic uh wide

2233
01:25:04,310 --> 01:25:01,199
field instrument

2234
01:25:06,709 --> 01:25:04,320
uh that doesn't have a

2235
01:25:07,430 --> 01:25:06,719
um it doesn't have a slit to block out

2236
01:25:10,470 --> 01:25:07,440
the sky

2237
01:25:13,270 --> 01:25:10,480
but it um it can cover a lot of area so

2238
01:25:16,950 --> 01:25:13,280

that's a very popular technique

2239
01:25:19,750 --> 01:25:16,960
more of more of a survey kind of

2240
01:25:21,189 --> 01:25:19,760
instrument and it's specifically aimed

2241
01:25:24,629 --> 01:25:21,199
at getting

2242
01:25:26,790 --> 01:25:24,639
the redshifts of galaxies that will be

2243
01:25:29,430 --> 01:25:26,800
used to map out this structure

2244
01:25:31,189 --> 01:25:29,440
uh to measure dark energy via what's

2245
01:25:33,990 --> 01:25:31,199
called acoustic baryon acoustic

2246
01:25:37,430 --> 01:25:34,000
oscillation so it's a signature

2247
01:25:40,229 --> 01:25:37,440
a strong signature of of clustering

2248
01:25:42,470 --> 01:25:40,239
that we can use as a standard ruler but

2249
01:25:44,950 --> 01:25:42,480
will also tell us about

2250
01:25:47,510 --> 01:25:44,960
sort of the evolution a little bit about

2251
01:25:49,669 --> 01:25:47,520
the evolution of galaxies through

2252
01:25:51,350 --> 01:25:49,679
studying the strengths of those lines

2253
01:25:53,750 --> 01:25:51,360
and how they evolve

2254
01:25:56,870 --> 01:25:53,760
and may also be helpful for identifying

2255
01:25:58,390 --> 01:25:56,880
what kind of supernova it is you saw

2256
01:26:02,870 --> 01:25:58,400
so i don't know if any other people want

2257
01:26:08,310 --> 01:26:05,990
well i could say um a little bit we have

2258
01:26:11,430 --> 01:26:08,320
to um we

2259
01:26:13,030 --> 01:26:11,440
as you mentioned we are spectroscopy is

2260
01:26:15,910 --> 01:26:13,040
flitless but we have two

2261
01:26:17,510 --> 01:26:15,920
um we have both grism and a prism and

2262
01:26:18,709 --> 01:26:17,520
the distinction between them is a

2263
01:26:20,629 --> 01:26:18,719

trade-off between

2264
01:26:22,470 --> 01:26:20,639
um sensitivity to narrow lines versus

2265
01:26:25,510 --> 01:26:22,480
sensitivity to broad features

2266
01:26:27,830 --> 01:26:25,520
so that we have uh one method that is

2267
01:26:29,189 --> 01:26:27,840
optimized for narrow emission lines so

2268
01:26:32,310 --> 01:26:29,199
then a second

2269
01:26:33,910 --> 01:26:32,320
uh channel that is optimized for finding

2270
01:26:40,149 --> 01:26:33,920
the more broad features that we see

2271
01:26:45,910 --> 01:26:43,510
thank you and my last question is for

2272
01:26:47,189 --> 01:26:45,920
dr somerville i was wondering when you

2273
01:26:50,550 --> 01:26:47,199
were talking about the

2274
01:26:52,470 --> 01:26:50,560
era of reionization one of the

2275
01:26:54,629 --> 01:26:52,480
key questions that you mentioned was

2276
01:26:54,950 --> 01:26:54,639
what are the sources of the photons that

2277
01:26:57,990 --> 01:26:54,960
are

2278
01:27:00,310 --> 01:26:58,000
causing the ionization

2279
01:27:02,310 --> 01:27:00,320
so are we trying to identify what types

2280
01:27:04,629 --> 01:27:02,320
of stars were involved or are there

2281
01:27:05,189 --> 01:27:04,639
other sources in addition to stars that

2282
01:27:08,390 --> 01:27:05,199
we're

2283
01:27:11,189 --> 01:27:08,400
considering so

2284
01:27:11,990 --> 01:27:11,199
um we think at this point that it was

2285
01:27:16,229 --> 01:27:12,000
probably

2286
01:27:17,110 --> 01:27:16,239
mostly stars but people sometimes make a

2287
01:27:21,590 --> 01:27:17,120
distinction

2288
01:27:24,790 --> 01:27:21,600

between the very first stars so what

2289
01:27:26,629 --> 01:27:24,800
adam mentioned the pop3 stars which form

2290
01:27:27,990 --> 01:27:26,639
out of pure hydrogen and helium and

2291
01:27:29,110 --> 01:27:28,000
might have been very massive and

2292
01:27:32,229 --> 01:27:29,120
luminous and

2293
01:27:35,270 --> 01:27:32,239
emit extra ionizing photons

2294
01:27:36,870 --> 01:27:35,280
um versus sort of normal stars stars

2295
01:27:38,950 --> 01:27:36,880
more like the stars that are around us

2296
01:27:40,149 --> 01:27:38,960
today or maybe something in between

2297
01:27:42,149 --> 01:27:40,159
right there may have been

2298
01:27:43,669 --> 01:27:42,159
a mix of of different kinds of

2299
01:27:47,270 --> 01:27:43,679
populations

2300
01:27:48,470 --> 01:27:47,280
in addition however accreting black

2301
01:27:50,709 --> 01:27:48,480
holes are also

2302
01:27:52,470 --> 01:27:50,719
very good at producing ionizing photons

2303
01:27:53,910 --> 01:27:52,480
because they produce this very high

2304
01:27:56,070 --> 01:27:53,920
energy radiation

2305
01:27:57,910 --> 01:27:56,080
now we don't think that they were common

2306
01:27:59,830 --> 01:27:57,920
enough at these early times to

2307
01:28:01,270 --> 01:27:59,840
significantly contribute to hydrogen

2308
01:28:03,830 --> 01:28:01,280
reionization but

2309
01:28:05,590 --> 01:28:03,840
you know it would be interesting to

2310
01:28:08,790 --> 01:28:05,600
better constrain the contribution also

2311
01:28:11,990 --> 01:28:08,800
coming from black holes

2312
01:28:15,350 --> 01:28:12,000
and just a little note to add to that um

2313
01:28:16,310 --> 01:28:15,360

if you'd asked people five or six years

2314
01:28:19,350 --> 01:28:16,320
ago

2315
01:28:20,550 --> 01:28:19,360
uh whether it was uh stars or early

2316
01:28:22,470 --> 01:28:20,560
galaxies

2317
01:28:24,790 --> 01:28:22,480
uh most people thought there was a a

2318
01:28:26,830 --> 01:28:24,800
crisis that things didn't add up

2319
01:28:29,189 --> 01:28:26,840
and that you just didn't have enough

2320
01:28:30,870 --> 01:28:29,199
escaping high energy photons from

2321
01:28:33,590 --> 01:28:30,880
galaxies

2322
01:28:35,830 --> 01:28:33,600
we now think that there are mostly from

2323
01:28:40,149 --> 01:28:35,840
surveys from hubble

2324
01:28:41,830 --> 01:28:40,159
but if it if that budget doesn't add up

2325
01:28:43,350 --> 01:28:41,840
as we measure it more and more precisely

2326
01:28:44,709 --> 01:28:43,360
then you need something else and that

2327
01:28:46,709 --> 01:28:44,719
something else could be something as

2328
01:28:47,430 --> 01:28:46,719
exotic as decaying dark matter which

2329
01:28:50,550 --> 01:28:47,440
would be

2330
01:28:51,270 --> 01:28:50,560
you know new fundamental physics uh so

2331
01:28:54,950 --> 01:28:51,280
you're always

2332
01:28:57,830 --> 01:28:54,960
more precise measurements to

2333
01:29:01,189 --> 01:28:57,840
to test the limits of you know do things

2334
01:29:08,870 --> 01:29:04,790
all right uh we have a follow-up in the

2335
01:29:11,590 --> 01:29:08,880
chat um for adam where do jwst

2336
01:29:13,669 --> 01:29:11,600
elt and others stand in relation to

2337
01:29:15,910 --> 01:29:13,679
roman when it comes to pinning down dark

2338
01:29:17,669 --> 01:29:15,920

energy and are you optimistic about

2339
01:29:21,590 --> 01:29:17,679
getting to the bottom of this

2340
01:29:22,790 --> 01:29:21,600
while in my lifetime my lifetime too

2341
01:29:25,270 --> 01:29:22,800
well i don't know who's asking so i

2342
01:29:28,629 --> 01:29:25,280
don't know how long their lifetime is um

2343
01:29:30,390 --> 01:29:28,639
but uh uh anyway the answer is roman is

2344
01:29:33,750 --> 01:29:30,400
just much better suited than

2345
01:29:37,270 --> 01:29:33,760
jwst or an elt to study dark energy

2346
01:29:39,990 --> 01:29:37,280
dark energy is really about measuring

2347
01:29:41,830 --> 01:29:40,000
a lot of very weak signals uh that you

2348
01:29:42,709 --> 01:29:41,840
have to add up statistically to get a

2349
01:29:46,229 --> 01:29:42,719
handle on

2350
01:29:48,550 --> 01:29:46,239
uh dark energy whereas you know jwst

2351
01:29:49,830 --> 01:29:48,560
and elt both will have small fields of

2352
01:29:53,110 --> 01:29:49,840
view they will study

2353
01:29:54,149 --> 01:29:53,120
you know intensely exciting individual

2354
01:29:57,030 --> 01:29:54,159
objects from

2355
01:29:58,310 --> 01:29:57,040
sort of the edge of time but uh they

2356
01:30:00,470 --> 01:29:58,320
won't give us that same

2357
01:30:01,590 --> 01:30:00,480
you know gulp of the universe that roman

2358
01:30:04,550 --> 01:30:01,600
will um

2359
01:30:04,950 --> 01:30:04,560
and in terms of our lifetimes um you

2360
01:30:06,790 --> 01:30:04,960
know

2361
01:30:08,470 --> 01:30:06,800
it really depends on what the answer is

2362
01:30:11,590 --> 01:30:08,480
this is one of those situations

2363
01:30:13,510 --> 01:30:11,600

if uh we managed to break

2364
01:30:15,350 --> 01:30:13,520
the current uh understanding of dark

2365
01:30:16,070 --> 01:30:15,360
energy that it's not the cosmological

2366
01:30:17,669 --> 01:30:16,080
constant

2367
01:30:19,430 --> 01:30:17,679
uh that could happen very soon it could

2368
01:30:22,390 --> 01:30:19,440
happen after the launch of roman

2369
01:30:23,510 --> 01:30:22,400
or or one of the other uh observatories

2370
01:30:24,950 --> 01:30:23,520
like reuben and that would be

2371
01:30:26,790 --> 01:30:24,960
tremendously exciting

2372
01:30:28,310 --> 01:30:26,800
if uh it continues to look like a

2373
01:30:31,830 --> 01:30:28,320
cosmological constant

2374
01:30:33,110 --> 01:30:31,840
uh then as i described at some point um

2375
01:30:35,430 --> 01:30:33,120
you know we will be beaten into

2376
01:30:37,030 --> 01:30:35,440
submission in uh seeing that and

2377
01:30:43,590 --> 01:30:37,040
you know i can't give exactly the time

2378
01:30:50,950 --> 01:30:47,590
okay let's see

2379
01:30:53,510 --> 01:30:50,960
um can the panel briefly talk about how

2380
01:30:54,870 --> 01:30:53,520
such a vast archive of data immediately

2381
01:30:56,870 --> 01:30:54,880
available will provide

2382
01:31:07,030 --> 01:30:56,880
opportunities for scientists from

2383
01:31:12,470 --> 01:31:10,229
i'll take a stab at that um so

2384
01:31:13,990 --> 01:31:12,480
we had a really interesting talk at the

2385
01:31:18,149 --> 01:31:14,000
conference this morning

2386
01:31:21,430 --> 01:31:18,159
by dara norman who is pointing out

2387
01:31:24,790 --> 01:31:21,440
what a huge force for inclusion and

2388
01:31:27,910 --> 01:31:24,800

equity it will be to have these archives

2389
01:31:28,550 --> 01:31:27,920
of science-ready data products so this

2390
01:31:32,470 --> 01:31:28,560
will

2391
01:31:34,229 --> 01:31:32,480
really remove many of the barriers to

2392
01:31:35,910 --> 01:31:34,239
access that are currently there for

2393
01:31:37,669 --> 01:31:35,920
people who might be at smaller

2394
01:31:39,669 --> 01:31:37,679
institutions or people who might not

2395
01:31:42,229 --> 01:31:39,679
have the specialized background

2396
01:31:42,950 --> 01:31:42,239
to do a specific kind of data processing

2397
01:31:44,709 --> 01:31:42,960
and really just

2398
01:31:46,149 --> 01:31:44,719
enable a huge amount of science and

2399
01:31:48,629 --> 01:31:46,159
hopefully get more

2400
01:31:49,750 --> 01:31:48,639
people and more diverse kinds of people

2401
01:31:51,590 --> 01:31:49,760
from all over the world

2402
01:31:54,550 --> 01:31:51,600
involved in doing science so i think

2403
01:31:56,629 --> 01:31:54,560
it's extremely positive

2404
01:31:57,669 --> 01:31:56,639
i've got a follow-up question if i may

2405
01:32:00,950 --> 01:31:57,679
rachel

2406
01:32:03,430 --> 01:32:00,960
um what there's

2407
01:32:04,310 --> 01:32:03,440
mass is a amount of data that's going to

2408
01:32:08,550 --> 01:32:04,320
come from

2409
01:32:15,189 --> 01:32:11,750
what what is the plan for uh

2410
01:32:17,510 --> 01:32:15,199
for cutting edge software to manage

2411
01:32:18,790 --> 01:32:17,520
and to search through and to data mine

2412
01:32:24,629 --> 01:32:18,800
these

2413
01:32:30,070 --> 01:32:27,590

i i used to work for the archive space

2414
01:32:30,390 --> 01:32:30,080
telescope many years ago but i no longer

2415
01:32:32,870 --> 01:32:30,400
do

2416
01:32:34,229 --> 01:32:32,880
so i am not a person to answer that

2417
01:32:36,390 --> 01:32:34,239
question but maybe

2418
01:32:37,830 --> 01:32:36,400
someone else on our panel can i'll take

2419
01:32:40,390 --> 01:32:37,840
a hack at it um

2420
01:32:41,110 --> 01:32:40,400
i mean you've identified a big challenge

2421
01:32:48,229 --> 01:32:41,120
um

2422
01:32:53,750 --> 01:32:51,669
the side of the the project that uh

2423
01:32:55,590 --> 01:32:53,760
sort of runs the the mission and the

2424
01:32:56,950 --> 01:32:55,600
data management we will be producing

2425
01:32:58,870 --> 01:32:56,960
standard products

2426
01:33:00,790 --> 01:32:58,880
that hopefully are ready for science

2427
01:33:02,550 --> 01:33:00,800
meaning that they will have a catalog

2428
01:33:03,430 --> 01:33:02,560
they'll have images that are cleaned of

2429
01:33:06,870 --> 01:33:03,440
the

2430
01:33:10,390 --> 01:33:06,880
detector signatures and things like that

2431
01:33:14,709 --> 01:33:10,400
um but the sort of mining of the data

2432
01:33:17,990 --> 01:33:14,719
um where you say okay i i would like to

2433
01:33:22,390 --> 01:33:18,000
um query

2434
01:33:24,870 --> 01:33:22,400
every pixel in some new way

2435
01:33:26,870 --> 01:33:24,880
um that that's something that really the

2436
01:33:29,669 --> 01:33:26,880
community has to

2437
01:33:30,629 --> 01:33:29,679
figure out how to do um and it's not

2438
01:33:33,350 --> 01:33:30,639

just for

2439
01:33:34,950 --> 01:33:33,360
for roman but for reuben which has a

2440
01:33:38,390 --> 01:33:34,960
data volume that's

2441
01:33:41,110 --> 01:33:38,400
you know much much larger um that it

2442
01:33:43,189 --> 01:33:41,120
we don't yet know of a way to enable

2443
01:33:46,790 --> 01:33:43,199
people to look at every pixel

2444
01:33:48,390 --> 01:33:46,800
uh in in any you know

2445
01:33:49,669 --> 01:33:48,400
computationally challenging way because

2446
01:33:51,910 --> 01:33:49,679
they're just too many pixels it takes

2447
01:33:54,550 --> 01:33:51,920
too much computation

2448
01:33:55,990 --> 01:33:54,560
but we may be able to use machine

2449
01:33:59,350 --> 01:33:56,000
learning techniques

2450
01:34:01,430 --> 01:33:59,360
to enable that um and it's something we

2451
01:34:02,790 --> 01:34:01,440
you know we as an astronomy community

2452
01:34:05,030 --> 01:34:02,800
have to work on

2453
01:34:07,189 --> 01:34:05,040
to just to figure out you know how to

2454
01:34:10,310 --> 01:34:07,199
attack this volume of data

2455
01:34:11,430 --> 01:34:10,320
um so yeah there are lots of ideas

2456
01:34:14,470 --> 01:34:11,440
floating out there

2457
01:34:17,990 --> 01:34:14,480
about how you might approach it um

2458
01:34:21,510 --> 01:34:18,000
but there is not a one pat solution

2459
01:34:24,149 --> 01:34:21,520
to that thank you just add

2460
01:34:25,910 --> 01:34:24,159
it's a fabulous problem to have that you

2461
01:34:33,189 --> 01:34:25,920
have so much high quality data that you

2462
01:34:35,430 --> 01:34:33,199
don't know how to manage it

2463
01:34:39,350 --> 01:34:35,440

it's the best problem to have given what

2464
01:34:45,109 --> 01:34:41,990
and the mast archives i think does a

2465
01:34:48,390 --> 01:34:45,119
phenomenal job with a lot of that um

2466
01:34:50,070 --> 01:34:48,400
can we i don't see any more questions

2467
01:34:53,270 --> 01:34:50,080
from the audience if you have anything

2468
01:34:54,950 --> 01:34:53,280
pop it in but i'll defer to christine on

2469
01:34:58,470 --> 01:34:54,960
whether we should or should not or if

2470
01:35:01,910 --> 01:35:01,189
uh yep there being no further questions

2471
01:35:03,430 --> 01:35:01,920
uh

2472
01:35:05,990 --> 01:35:03,440
we are going to go ahead and wrap up the

2473
01:35:07,870 --> 01:35:06,000
workshop um i want to

2474
01:35:09,270 --> 01:35:07,880
thank our speakers for their

2475
01:35:11,990 --> 01:35:09,280
presentations

2476
01:35:13,430 --> 01:35:12,000
i thought they were very enlightening um

2477
01:35:16,229 --> 01:35:13,440
thank you to

2478
01:35:16,629 --> 01:35:16,239
you grant and thomas our tech team and

2479
01:35:19,430 --> 01:35:16,639
uh

2480
01:35:21,270 --> 01:35:19,440
thank you to everyone who tuned in um i

2481
01:35:23,030 --> 01:35:21,280
just want to remind you that

2482
01:35:25,030 --> 01:35:23,040
as i think i mentioned at the start this

2483
01:35:27,990 --> 01:35:25,040
workshop is going to be archived here

2484
01:35:28,870 --> 01:35:28,000
on youtube uh we'll be re-uploading a

2485
01:35:31,590 --> 01:35:28,880
fresh video

2486
01:35:33,510 --> 01:35:31,600
um so that will go to the hubble channel

2487
01:35:35,669 --> 01:35:33,520
and you can also find more information

2488
01:35:39,510 --> 01:35:35,679

about the roman space telescope online