



1
00:00:09,270 --> 00:00:07,030
good afternoon

2
00:00:10,870 --> 00:00:09,280
welcome to nasa headquarters

3
00:00:12,470 --> 00:00:10,880
my name is duane brown with the office

4
00:00:16,150 --> 00:00:12,480
of communications

5
00:00:18,710 --> 00:00:16,160
and today you will hear an amazing story

6
00:00:22,470 --> 00:00:18,720
about amazing spacecraft

7
00:00:24,310 --> 00:00:22,480
told by amazing people

8
00:00:26,230 --> 00:00:24,320
today's story

9
00:00:27,830 --> 00:00:26,240
the voyager spacecraft

10
00:00:28,830 --> 00:00:27,840
humanity's

11
00:00:31,990 --> 00:00:28,840
father's

12
00:00:33,430 --> 00:00:32,000
journey after 33 years in space they are

13
00:00:35,750 --> 00:00:33,440

still operating

14

00:00:38,709 --> 00:00:35,760

and returning data billions

15

00:00:41,110 --> 00:00:38,719

of miles away from our sun

16

00:00:44,549 --> 00:00:41,120

they also carry a collection of images

17

00:00:46,709 --> 00:00:44,559

and sounds from earth as a message to

18

00:00:48,549 --> 00:00:46,719

possible life elsewhere

19

00:00:50,310 --> 00:00:48,559

in the galaxy

20

00:00:53,029 --> 00:00:50,320

we have a lot to cover today

21

00:00:55,670 --> 00:00:53,039

so sit back

22

00:00:58,630 --> 00:00:55,680

and be prepared for a wonderful story

23

00:01:00,630 --> 00:00:58,640

and the first chapter will be given by

24

00:01:02,630 --> 00:01:00,640

ed stone

25

00:01:04,789 --> 00:01:02,640

larger project scientist

26

00:01:08,550 --> 00:01:04,799

and professor of physics

27

00:01:10,710 --> 00:01:08,560

california institute of technology

28

00:01:12,870 --> 00:01:10,720

suzanne dodd

29

00:01:14,710 --> 00:01:12,880

for your project manager

30

00:01:17,990 --> 00:01:14,720

the jet propulsion laboratory in

31

00:01:19,749 --> 00:01:18,000

pasadena california

32

00:01:22,390 --> 00:01:19,759

marav offer

33

00:01:24,710 --> 00:01:22,400

forager guest investigator and assistant

34

00:01:27,429 --> 00:01:24,720

professor of astronomy

35

00:01:29,910 --> 00:01:27,439

boston university

36

00:01:31,590 --> 00:01:29,920

and drean

37

00:01:34,950 --> 00:01:31,600

creative director

38

00:01:37,590 --> 00:01:34,960

ward your interstellar message project

39

00:01:39,270 --> 00:01:37,600

and the late carl sagan's co-author

40

00:01:41,270 --> 00:01:39,280

and widow

41

00:01:44,630 --> 00:01:41,280

so to get us started on that first

42

00:01:46,230 --> 00:01:44,640

chapter i turn it over to edstone

43

00:01:48,389 --> 00:01:46,240

well it's been as a scientist it's

44

00:01:50,469 --> 00:01:48,399

really been an incredible uh experience

45

00:01:54,069 --> 00:01:50,479

to have been the chief scientist of the

46

00:01:56,230 --> 00:01:54,079

voyager mission since it began in 1972.

47

00:01:58,469 --> 00:01:56,240

and it's especially remarkable that

48

00:02:00,469 --> 00:01:58,479

nearly 40 years later the voyage of

49

00:02:03,670 --> 00:02:00,479

discovery continues

50

00:02:06,230 --> 00:02:03,680

today voyager 1 is 11 billion miles from

51
00:02:08,309 --> 00:02:06,240
the sun and voyager 2 is 9 billion miles

52
00:02:11,110 --> 00:02:08,319
from the sun but as the first graphic

53
00:02:13,430 --> 00:02:11,120
shows even so they are still within the

54
00:02:14,630 --> 00:02:13,440
bubble that the sun creates around

55
00:02:17,030 --> 00:02:14,640
itself

56
00:02:19,270 --> 00:02:17,040
the blue area is that bubble it's called

57
00:02:21,670 --> 00:02:19,280
the heliosphere the wind from the sun

58
00:02:23,510 --> 00:02:21,680
blows outward a million miles per hour

59
00:02:25,270 --> 00:02:23,520
and creates this bubble

60
00:02:26,949 --> 00:02:25,280
and as you can see in the in the

61
00:02:29,190 --> 00:02:26,959
animation that the two voyager

62
00:02:31,190 --> 00:02:29,200
spacecraft are in the outermost layer of

63
00:02:32,949 --> 00:02:31,200

that bubble uh heading toward

64

00:02:35,110 --> 00:02:32,959

interstellar space which is the bright

65

00:02:37,509 --> 00:02:35,120

region outside

66

00:02:38,309 --> 00:02:37,519

the mission started many years ago in

67

00:02:40,390 --> 00:02:38,319

fact

68

00:02:43,509 --> 00:02:40,400

the spacecraft were launched

69

00:02:45,350 --> 00:02:43,519

in 1977 that was a very special year

70

00:02:47,430 --> 00:02:45,360

when the planets outer planets were

71

00:02:50,869 --> 00:02:47,440

lined up so a single spacecraft could

72

00:02:53,430 --> 00:02:50,879

fly by all four jupiter saturn uranus

73

00:02:56,309 --> 00:02:53,440

and neptune that's called the grand tour

74

00:02:58,630 --> 00:02:56,319

but we didn't start out with that as the

75

00:03:00,790 --> 00:02:58,640

ultimate goal we started out with a more

76

00:03:02,869 --> 00:03:00,800

a near-term goal of just getting to

77

00:03:04,630 --> 00:03:02,879

saturn a four-year mission to saturn

78

00:03:07,350 --> 00:03:04,640

both spacecraft as you can see in the

79

00:03:09,110 --> 00:03:07,360

graphic flew by jupiter got a boost on

80

00:03:11,190 --> 00:03:09,120

the way to saturn

81

00:03:12,790 --> 00:03:11,200

voyager 1 went behind the rings and

82

00:03:15,190 --> 00:03:12,800

therefore went up out of the plane of

83

00:03:17,190 --> 00:03:15,200

the planets no more planetary encounters

84

00:03:19,190 --> 00:03:17,200

but when it succeeded in its mission

85

00:03:21,910 --> 00:03:19,200

that allows us to keep voyager 2 in the

86

00:03:24,550 --> 00:03:21,920

plane of the planets to continue on to

87

00:03:26,789 --> 00:03:24,560

uranus which is 19 times as far from the

88

00:03:29,430 --> 00:03:26,799

sun as earth and then finally on to

89

00:03:31,270 --> 00:03:29,440

neptune where it over the pole and

90

00:03:33,030 --> 00:03:31,280

downwards so we have a spacecraft

91

00:03:35,350 --> 00:03:33,040

heading out the interstellar space

92

00:03:38,390 --> 00:03:35,360

heading south that's voyager 2 and one

93

00:03:41,350 --> 00:03:38,400

heading north toward interstellar space

94

00:03:43,190 --> 00:03:41,360

the next uh in the next uh

95

00:03:46,070 --> 00:03:43,200

short sequence we'll show you some of

96

00:03:46,869 --> 00:03:46,080

the things which we saw on this journey

97

00:03:50,789 --> 00:03:46,879

uh

98

00:03:53,110 --> 00:03:50,799

there was jupiter the largest of the

99

00:03:55,670 --> 00:03:53,120

giant planets the mystery of the great

100

00:03:58,390 --> 00:03:55,680

red spot what we discovered was it's a

101
00:04:00,630 --> 00:03:58,400
huge hurricane-like storm system three

102
00:04:03,509 --> 00:04:00,640
earths across but it's just one of many

103
00:04:05,350 --> 00:04:03,519
such storm systems saturn we flew by

104
00:04:07,750 --> 00:04:05,360
saturn's rings and discovered it's made

105
00:04:11,030 --> 00:04:07,760
up of countless particles of icy stuff

106
00:04:13,670 --> 00:04:11,040
bbs marbles snowballs some things as

107
00:04:15,910 --> 00:04:13,680
large as houses on to

108
00:04:17,909 --> 00:04:15,920
uranus which is tipped on its side with

109
00:04:19,830 --> 00:04:17,919
its north with his pole facing the sun

110
00:04:22,310 --> 00:04:19,840
so it's like a target in the sky when we

111
00:04:24,390 --> 00:04:22,320
flew by in 1986.

112
00:04:26,950 --> 00:04:24,400
one of the major discoveries was the

113
00:04:29,030 --> 00:04:26,960

magnetic pole of uranus is nearer its

114

00:04:30,070 --> 00:04:29,040

equator than its rotational axis and of

115

00:04:32,070 --> 00:04:30,080

course

116

00:04:34,870 --> 00:04:32,080

earth jupiter and saturn the magnetic

117

00:04:36,870 --> 00:04:34,880

pole is up where the rotation axis is uh

118

00:04:40,070 --> 00:04:36,880

on to neptune

119

00:04:42,070 --> 00:04:40,080

the most remote giant planet uh 30 times

120

00:04:45,030 --> 00:04:42,080

as far from the sun as the earth so cold

121

00:04:47,510 --> 00:04:45,040

we expect to be very very quiescent but

122

00:04:49,110 --> 00:04:47,520

in fact it has the fastest winds in the

123

00:04:51,110 --> 00:04:49,120

solar system even though it has the

124

00:04:53,030 --> 00:04:51,120

least energy to drive the winds and it

125

00:04:53,909 --> 00:04:53,040

had a great dark spot

126
00:04:56,550 --> 00:04:53,919
so the

127
00:04:58,469 --> 00:04:56,560
the this journey was really just full of

128
00:05:00,310 --> 00:04:58,479
surprises as we learned things we didn't

129
00:05:02,070 --> 00:05:00,320
know there were there to be learned and

130
00:05:04,150 --> 00:05:02,080
there were two bookends which sort of

131
00:05:06,310 --> 00:05:04,160
illustrate that the first book end is

132
00:05:08,310 --> 00:05:06,320
isle a moon of jupiter

133
00:05:10,150 --> 00:05:08,320
until that time the only active

134
00:05:12,629 --> 00:05:10,160
volcanoes known in the solar system were

135
00:05:15,590 --> 00:05:12,639
right here on earth but when we flew by

136
00:05:17,350 --> 00:05:15,600
isle we discovered that there were eight

137
00:05:19,909 --> 00:05:17,360
active volcanoes some of them as you can

138
00:05:22,790 --> 00:05:19,919

see erupting hundreds of miles above the

139

00:05:24,950 --> 00:05:22,800

surface of this tiny little world and

140

00:05:27,029 --> 00:05:24,960

the other bookend was the last body we

141

00:05:30,670 --> 00:05:27,039

made we visited which is triton it's a

142

00:05:34,390 --> 00:05:30,680

pluto-sized moon of neptune so cold

143

00:05:36,629 --> 00:05:34,400

390 degrees fahrenheit below zero that

144

00:05:39,270 --> 00:05:36,639

even the nitrogen forms the icy polar

145

00:05:42,310 --> 00:05:39,280

cap that you see but those dark streaks

146

00:05:46,629 --> 00:05:42,320

of that icy polar cap are the deposits

147

00:05:49,749 --> 00:05:46,639

of geysers erupting at 390 degrees below

148

00:05:52,790 --> 00:05:49,759

zero on this icy world just an example

149

00:05:55,590 --> 00:05:52,800

of the how remarkably diverse the bodies

150

00:05:57,830 --> 00:05:55,600

are in the solar system familiar in form

151

00:05:59,510 --> 00:05:57,840

but diverse in detail and has really

152

00:06:00,950 --> 00:05:59,520

changed our whole view of the solar

153

00:06:03,430 --> 00:06:00,960

system in the textbooks which have

154

00:06:05,270 --> 00:06:03,440

written been written since that time

155

00:06:07,270 --> 00:06:05,280

but that was not the end of our journey

156

00:06:09,749 --> 00:06:07,280

of exploration there was still the

157

00:06:12,070 --> 00:06:09,759

heliosphere i can't show you a picture

158

00:06:14,150 --> 00:06:12,080

of the heliosphere but i can show you a

159

00:06:16,550 --> 00:06:14,160

video of our kitchen sink so if we could

160

00:06:18,629 --> 00:06:16,560

have the next video because it is you

161

00:06:20,150 --> 00:06:18,639

can see the heliosphere in it where the

162

00:06:21,909 --> 00:06:20,160

water hits the bottom of the sink you'll

163

00:06:24,469 --> 00:06:21,919

notice the water is flowing really

164

00:06:27,430 --> 00:06:24,479

outward very fast just like the solar

165

00:06:29,510 --> 00:06:27,440

wind but eventually it slows down but it

166

00:06:32,550 --> 00:06:29,520

slows down abruptly in the shock and

167

00:06:33,990 --> 00:06:32,560

piles up and forms a thick ring of water

168

00:06:36,230 --> 00:06:34,000

and it's in the thick ring that the

169

00:06:37,510 --> 00:06:36,240

water flows down the drain that's

170

00:06:39,990 --> 00:06:37,520

exactly what's happening in our

171

00:06:42,150 --> 00:06:40,000

heliosphere and if we if we could have

172

00:06:44,710 --> 00:06:42,160

the final graphic on this you'll see

173

00:06:47,510 --> 00:06:44,720

that the two voyager spacecraft are in

174

00:06:49,350 --> 00:06:47,520

the thick ring they're in that region

175

00:06:51,909 --> 00:06:49,360

just on the outs whoops that's not the

176
00:06:54,309 --> 00:06:51,919
video but just just on the outer edge of

177
00:06:57,270 --> 00:06:54,319
the bubble there where where they're

178
00:06:58,550 --> 00:06:57,280
about to break free of the solar system

179
00:07:00,870 --> 00:06:58,560
this now is a

180
00:07:02,309 --> 00:07:00,880
computer graphic of the same story where

181
00:07:04,710 --> 00:07:02,319
you can see the wind from the sun

182
00:07:07,589 --> 00:07:04,720
radially outward and then turning to

183
00:07:09,510 --> 00:07:07,599
flow down the tail the tail is the drain

184
00:07:11,270 --> 00:07:09,520
all of the solar wind has to go down the

185
00:07:13,510 --> 00:07:11,280
drain which is the tail

186
00:07:15,670 --> 00:07:13,520
outside in interstellar space there's

187
00:07:17,990 --> 00:07:15,680
another wind which is coming and flowing

188
00:07:20,710 --> 00:07:18,000

around this wind is slower

189

00:07:23,110 --> 00:07:20,720

but it's it's still a very fast wind

190

00:07:24,230 --> 00:07:23,120

flowing around outside the heliosphere

191

00:07:25,749 --> 00:07:24,240

itself

192

00:07:28,309 --> 00:07:25,759

so there's a separation between the

193

00:07:30,870 --> 00:07:28,319

inside and the outside so what else is

194

00:07:33,510 --> 00:07:30,880

outside what's outside is really the

195

00:07:35,510 --> 00:07:33,520

result of a cloud which in the next

196

00:07:37,749 --> 00:07:35,520

graphic we can see the cloud

197

00:07:41,589 --> 00:07:37,759

which is the artist sketch of what we

198

00:07:43,189 --> 00:07:41,599

believe is outside uh by frisch and huff

199

00:07:44,950 --> 00:07:43,199

based on data they've taken from

200

00:07:47,189 --> 00:07:44,960

earth-based telescopes

201
00:07:48,469 --> 00:07:47,199
and there's the sun it's moving around

202
00:07:50,390 --> 00:07:48,479
the galaxy

203
00:07:52,309 --> 00:07:50,400
and also there's this cloud which is it

204
00:07:55,110 --> 00:07:52,319
just enveloped the heliosphere about a

205
00:07:57,830 --> 00:07:55,120
hundred thousand years ago uh that cloud

206
00:08:00,629 --> 00:07:57,840
was formed by the explosion of a new

207
00:08:03,029 --> 00:08:00,639
number of nearby massive stars five to

208
00:08:05,749 --> 00:08:03,039
ten million years ago they ejected most

209
00:08:08,550 --> 00:08:05,759
of their uh atmosphere and created these

210
00:08:10,309 --> 00:08:08,560
uh these clouds and that cloud is is

211
00:08:12,230 --> 00:08:10,319
essentially moving and enveloping our

212
00:08:14,390 --> 00:08:12,240
solar system

213
00:08:16,790 --> 00:08:14,400

so we are trying to get outside of our

214

00:08:19,749 --> 00:08:16,800

bubble into interstellar space to

215

00:08:22,150 --> 00:08:19,759

directly measure what is there uh the

216

00:08:23,990 --> 00:08:22,160

next final slide i want to show is an

217

00:08:26,230 --> 00:08:24,000

example of what one of these things look

218

00:08:28,469 --> 00:08:26,240

like this is actually a wise image of an

219

00:08:30,629 --> 00:08:28,479

astrosphere around that star there's an

220

00:08:32,870 --> 00:08:30,639

invisible bubble you cannot see but you

221

00:08:34,630 --> 00:08:32,880

can see where the interstellar wind is

222

00:08:36,709 --> 00:08:34,640

creating a bow shock in front of this

223

00:08:38,709 --> 00:08:36,719

thing that cannot be seen

224

00:08:41,430 --> 00:08:38,719

we don't know how long it much longer it

225

00:08:44,310 --> 00:08:41,440

will take to get outside our bubble but

226

00:08:46,710 --> 00:08:44,320

every three years voyager 1 travels 1

227

00:08:49,509 --> 00:08:46,720

billion miles so we shouldn't have too

228

00:08:51,990 --> 00:08:49,519

many more years to wait before we

229

00:08:54,550 --> 00:08:52,000

pass the next major milestone in this

230

00:08:56,470 --> 00:08:54,560

humanities farthest journey

231

00:08:58,070 --> 00:08:56,480

so now i'd like to turn this to suzanne

232

00:08:59,590 --> 00:08:58,080

who will talk more about the spacecraft

233

00:09:01,910 --> 00:08:59,600

thank you ed um

234

00:09:03,350 --> 00:09:01,920

and uh i want to tell you that it's a

235

00:09:05,350 --> 00:09:03,360

pleasure to be here to talk to you about

236

00:09:08,470 --> 00:09:05,360

voyager today

237

00:09:11,990 --> 00:09:08,480

voyager was my first job as a young

238

00:09:14,630 --> 00:09:12,000

engineer a younger engineer

239

00:09:16,550 --> 00:09:14,640

coming out of college i started as an

240

00:09:18,470 --> 00:09:16,560

engineer before the uranus encounter and

241

00:09:20,230 --> 00:09:18,480

i've come a little bit full circle to

242

00:09:21,990 --> 00:09:20,240

come back as the

243

00:09:24,470 --> 00:09:22,000

project manager and i'm just excited to

244

00:09:25,110 --> 00:09:24,480

be here and i also think it's important

245

00:09:29,190 --> 00:09:25,120

to

246

00:09:30,470 --> 00:09:29,200

of voyager all the discoveries it's made

247

00:09:32,470 --> 00:09:30,480

in the past

248

00:09:34,150 --> 00:09:32,480

but uh voyager is still making

249

00:09:36,470 --> 00:09:34,160

discoveries and it's important to get

250

00:09:38,870 --> 00:09:36,480

that message across to the public this

251

00:09:41,190 --> 00:09:38,880

is not we're not flying voyager to fly

252

00:09:44,150 --> 00:09:41,200

an antique we're flying voyager to get

253

00:09:45,670 --> 00:09:44,160

new science information from it

254

00:09:47,910 --> 00:09:45,680

and i want to talk to you today a little

255

00:09:51,430 --> 00:09:47,920

bit about this spacecraft and how it's

256

00:09:53,509 --> 00:09:51,440

an incredible workhorse in how

257

00:09:55,670 --> 00:09:53,519

we continue to teach it new tricks and

258

00:09:57,430 --> 00:09:55,680

and have it redo old tricks after a very

259

00:10:00,310 --> 00:09:57,440

long period of time

260

00:10:02,150 --> 00:10:00,320

so as ed has mentioned um if i can have

261

00:10:05,269 --> 00:10:02,160

the first slide oh it's up excuse me as

262

00:10:08,310 --> 00:10:05,279

that is mentioned um uh the where

263

00:10:11,990 --> 00:10:08,320

voyager 1 is located currently is an

264

00:10:14,310 --> 00:10:12,000

area of the um heliosphere where we've

265

00:10:16,870 --> 00:10:14,320

now detected that there's no radial

266

00:10:19,110 --> 00:10:16,880

component to the solar wind so it's

267

00:10:22,069 --> 00:10:19,120

almost in a in a dead zone

268

00:10:25,910 --> 00:10:22,079

and uh we have asked the spacecraft to

269

00:10:27,990 --> 00:10:25,920

do uh help us measure that area by doing

270

00:10:30,829 --> 00:10:28,000

a maneuver that it hadn't done since

271

00:10:32,550 --> 00:10:30,839

1990 21 years ago

272

00:10:35,030 --> 00:10:32,560

um

273

00:10:36,310 --> 00:10:35,040

we are using the low energy charge

274

00:10:38,310 --> 00:10:36,320

particle and i'm going to show you on

275

00:10:39,990 --> 00:10:38,320

the spacecraft where that is the low

276
00:10:42,949 --> 00:10:40,000
energy charged particle instrument is

277
00:10:45,430 --> 00:10:42,959
located here under the instrument boom

278
00:10:47,750 --> 00:10:45,440
and it scans in a plane

279
00:10:48,790 --> 00:10:47,760
in this direction in this plane and so

280
00:10:51,190 --> 00:10:48,800
what we

281
00:10:52,790 --> 00:10:51,200
did just this past march

282
00:10:55,670 --> 00:10:52,800
is we

283
00:10:58,310 --> 00:10:55,680
we asked the spacecraft to maneuver and

284
00:11:00,710 --> 00:10:58,320
so we rotated it along its long axis we

285
00:11:03,509 --> 00:11:00,720
maneuvered it this direction

286
00:11:05,350 --> 00:11:03,519
about 70 degrees so it now scanned in a

287
00:11:08,470 --> 00:11:05,360
plane this way

288
00:11:09,910 --> 00:11:08,480

and so that way we're getting um

289

00:11:11,990 --> 00:11:09,920

we're sensing in the environment in

290

00:11:13,190 --> 00:11:12,000

three dimensions

291

00:11:15,430 --> 00:11:13,200

and

292

00:11:18,310 --> 00:11:15,440

so what we do with this maneuver is we

293

00:11:20,949 --> 00:11:18,320

we rotate it 70 degrees we hold it for

294

00:11:22,630 --> 00:11:20,959

three to five hours on gyros

295

00:11:24,310 --> 00:11:22,640

and then we continue the rotation all

296

00:11:26,389 --> 00:11:24,320

the way around until it gets back to its

297

00:11:31,269 --> 00:11:26,399

original point um

298

00:11:35,910 --> 00:11:33,590

so if i can have the next slide

299

00:11:39,750 --> 00:11:35,920

the last time we did this was back in

300

00:11:41,590 --> 00:11:39,760

1990 when voyager 1 before well just as

301
00:11:43,030 --> 00:11:41,600
it was leaving the solar system actually

302
00:11:45,829 --> 00:11:43,040
voyager 1 was out of the solar system

303
00:11:48,710 --> 00:11:45,839
but it was it was done in 1990 where we

304
00:11:51,430 --> 00:11:48,720
could take an image of all the planets

305
00:11:53,829 --> 00:11:51,440
of our solar system has has dots and put

306
00:11:56,069 --> 00:11:53,839
them all together in one image and i

307
00:11:58,150 --> 00:11:56,079
think as most people would agree this is

308
00:12:00,389 --> 00:11:58,160
one of the iconic images from the

309
00:12:03,190 --> 00:12:00,399
voyager spacecraft

310
00:12:05,269 --> 00:12:03,200
it really puts the your humanity in

311
00:12:07,590 --> 00:12:05,279
perspective of how small you are

312
00:12:09,750 --> 00:12:07,600
compared to how large our solar system

313
00:12:15,350 --> 00:12:09,760

is

314

00:12:17,269 --> 00:12:15,360

that

315

00:12:19,269 --> 00:12:17,279

every three months

316

00:12:22,069 --> 00:12:19,279

for the next three to five years until

317

00:12:23,829 --> 00:12:22,079

we reach hopefully reach the edge of the

318

00:12:25,670 --> 00:12:23,839

heliosphere and cross out into

319

00:12:28,389 --> 00:12:25,680

interstellar space

320

00:12:31,750 --> 00:12:28,399

if i can have the next slide please

321

00:12:33,509 --> 00:12:31,760

this image shows you some of the

322

00:12:35,910 --> 00:12:33,519

spacecraft that are traveled out the

323

00:12:37,590 --> 00:12:35,920

most distance from earth

324

00:12:39,910 --> 00:12:37,600

in the upper left-hand corner you can

325

00:12:41,829 --> 00:12:39,920

see voyager 1 it's going up and out of

326

00:12:43,910 --> 00:12:41,839

the ecliptic plane and in the lower

327

00:12:48,310 --> 00:12:43,920

left-hand corner you see voyager 2 it's

328

00:12:52,389 --> 00:12:49,990

and

329

00:12:55,430 --> 00:12:52,399

voyager 2 was actually launched ahead of

330

00:12:57,829 --> 00:12:55,440

voyager 1 by 16 days it's the older

331

00:13:00,230 --> 00:12:57,839

sibling by 16 days

332

00:13:01,190 --> 00:13:00,240

but it's on a slightly slower

333

00:13:03,030 --> 00:13:01,200

um

334

00:13:05,829 --> 00:13:03,040

it's flying out a slightly slower speed

335

00:13:09,190 --> 00:13:05,839

because it's on a different trajectory

336

00:13:10,949 --> 00:13:09,200

but voyager 2 has traveled for twelve

337

00:13:13,190 --> 00:13:10,959

thousand two hundred and seventy three

338

00:13:14,949 --> 00:13:13,200

days as of today

339

00:13:17,590 --> 00:13:14,959

and uh

340

00:13:18,949 --> 00:13:17,600

a voyager voyager one

341

00:13:21,829 --> 00:13:18,959

is the most

342

00:13:24,150 --> 00:13:21,839

distant spacecraft we have today

343

00:13:26,389 --> 00:13:24,160

it passed pioneer 10 in distance back in

344

00:13:29,030 --> 00:13:26,399

1998

345

00:13:30,990 --> 00:13:29,040

if you had an odometer on voyager 1 it

346

00:13:34,230 --> 00:13:31,000

would be measuring currently

347

00:13:37,750 --> 00:13:34,240

22.8 billion miles

348

00:13:39,829 --> 00:13:37,760

voyager 1 is 17.4 billion miles from the

349

00:13:42,710 --> 00:13:39,839

earth voyager 2 again is a little bit

350

00:13:43,670 --> 00:13:42,720

closer it's 14.2 billion miles from the

351
00:13:45,110 --> 00:13:43,680
earth

352
00:13:47,910 --> 00:13:45,120
and

353
00:13:49,350 --> 00:13:47,920
voyager 1 is giving you give you some

354
00:13:53,430 --> 00:13:49,360
speeds here uh

355
00:13:55,750 --> 00:13:53,440
is 61 000 uh over over 61 000 kilometers

356
00:13:57,910 --> 00:13:55,760
per hour is its speed and for voyager 2

357
00:14:00,230 --> 00:13:57,920
it's just slightly over 55 000

358
00:14:01,750 --> 00:14:00,240
kilometers of speed and the voyager

359
00:14:04,389 --> 00:14:01,760
spacecraft continue along with the

360
00:14:05,990 --> 00:14:04,399
pioneer spacecraft to travel out of our

361
00:14:07,670 --> 00:14:06,000
solar system

362
00:14:10,470 --> 00:14:07,680
next slide please

363
00:14:12,069 --> 00:14:10,480

so how do we talk to these spacecraft

364

00:14:13,750 --> 00:14:12,079

i got to give a shout out to the deep

365

00:14:16,310 --> 00:14:13,760

space network

366

00:14:18,150 --> 00:14:16,320

they're the real workhorses for us this

367

00:14:20,790 --> 00:14:18,160

is an image of

368

00:14:22,870 --> 00:14:20,800

the 70 meter antenna in goldstone

369

00:14:24,949 --> 00:14:22,880

california

370

00:14:27,670 --> 00:14:24,959

these antennas were actually upgraded

371

00:14:31,269 --> 00:14:27,680

from 64 meters to 70 meters back in the

372

00:14:33,829 --> 00:14:31,279

late 80s for the neptune encounter

373

00:14:35,910 --> 00:14:33,839

and because our spacecrafts are our

374

00:14:37,269 --> 00:14:35,920

spacecraft are so far away the signal is

375

00:14:39,269 --> 00:14:37,279

very very faint

376

00:14:40,629 --> 00:14:39,279

and so we need the largest antennas in

377

00:14:43,350 --> 00:14:40,639

order to

378

00:14:44,949 --> 00:14:43,360

track the spacecraft

379

00:14:47,590 --> 00:14:44,959

and i'm going to give you another kind

380

00:14:49,670 --> 00:14:47,600

of g whiz number here uh the time it

381

00:14:52,710 --> 00:14:49,680

takes for us to send a command from the

382

00:14:55,590 --> 00:14:52,720

earth for it to reach voyager 1

383

00:14:57,990 --> 00:14:55,600

is slightly over 16 hours

384

00:14:59,590 --> 00:14:58,000

and for voyager 2 it's slightly over 13

385

00:15:01,750 --> 00:14:59,600

hours

386

00:15:03,670 --> 00:15:01,760

so for us to send a command we go into

387

00:15:05,990 --> 00:15:03,680

the office monday morning we send a

388

00:15:08,470 --> 00:15:06,000

command to voyager1

389

00:15:10,629 --> 00:15:08,480

and voyager1 says yep i got it i'm going

390

00:15:13,189 --> 00:15:10,639

to send you a command back we get that

391

00:15:15,590 --> 00:15:13,199

command back on tuesday afternoon

392

00:15:17,590 --> 00:15:15,600

you know 32 hours later and to put that

393

00:15:20,150 --> 00:15:17,600

in perspective a typical mars mission

394

00:15:22,949 --> 00:15:20,160

has about a uh 10 minute

395

00:15:28,069 --> 00:15:22,959

one-way command time so we're a lot

396

00:15:32,389 --> 00:15:30,949

and if we enroll the last graphic i have

397

00:15:33,990 --> 00:15:32,399

what what void you're going to do in the

398

00:15:36,150 --> 00:15:34,000

future well

399

00:15:37,509 --> 00:15:36,160

we have enough power on board to

400

00:15:40,629 --> 00:15:37,519

continue operating the voyager

401
00:15:43,749 --> 00:15:40,639
spacecraft to 2020 and perhaps out even

402
00:15:46,790 --> 00:15:43,759
out to 2025

403
00:15:49,430 --> 00:15:46,800
the only fuel we use is really fuel for

404
00:15:52,069 --> 00:15:49,440
uh rotating the spacecraft

405
00:15:56,389 --> 00:15:52,079
and we use a hydrazine fuel there we use

406
00:15:59,030 --> 00:15:56,399
1.6 grams a day we have enough hydrazine

407
00:16:00,470 --> 00:15:59,040
fuel to last another 60 years so that's

408
00:16:03,110 --> 00:16:00,480
not going to be any kind of a limiting

409
00:16:04,310 --> 00:16:03,120
resource for voyager

410
00:16:06,870 --> 00:16:04,320
but we're hoping to operate the

411
00:16:08,629 --> 00:16:06,880
spacecraft out to 2020 and maybe a

412
00:16:10,949 --> 00:16:08,639
little bit longer and we want to get

413
00:16:13,030 --> 00:16:10,959

across the heliopause and we want to get

414

00:16:14,949 --> 00:16:13,040

out into interstellar space and take the

415

00:16:17,590 --> 00:16:14,959

first true

416

00:16:19,590 --> 00:16:17,600

measurements of interstellar space with

417

00:16:21,030 --> 00:16:19,600

an operating spacecraft and when we

418

00:16:22,870 --> 00:16:21,040

reach that point

419

00:16:26,230 --> 00:16:22,880

we'll be able to say that the voyagers

420

00:16:27,829 --> 00:16:26,240

are truly traveling between stars

421

00:16:29,189 --> 00:16:27,839

and now i'm going to hand it to morath

422

00:16:30,550 --> 00:16:29,199

and she's going to talk about her

423

00:16:31,509 --> 00:16:30,560

science

424

00:16:33,829 --> 00:16:31,519

thank you

425

00:16:36,470 --> 00:16:33,839

before i describe some of the latest

426

00:16:38,150 --> 00:16:36,480

discoveries that voyager gave us

427

00:16:41,910 --> 00:16:38,160

i thought on telling a little bit of my

428

00:16:45,430 --> 00:16:41,920

personal journey into the voyager team

429

00:16:47,269 --> 00:16:45,440

and and i hope i inspire another new not

430

00:16:49,590 --> 00:16:47,279

so young like me but

431

00:16:51,430 --> 00:16:49,600

younger people entering into the space

432

00:16:52,790 --> 00:16:51,440

science community and getting excited

433

00:16:55,509 --> 00:16:52,800

with voyager

434

00:16:57,350 --> 00:16:55,519

data and be engaged

435

00:16:59,910 --> 00:16:57,360

so and the next

436

00:17:02,389 --> 00:16:59,920

image show where i was around the time

437

00:17:05,350 --> 00:17:02,399

of voyager was launched i was back in

438

00:17:08,150 --> 00:17:05,360

brazil and this is an image i'm at the

439

00:17:11,189 --> 00:17:08,160

center my twin sister were all wearing

440

00:17:13,909 --> 00:17:11,199

the same shirt on my side and my dad

441

00:17:17,110 --> 00:17:13,919

he's also an astronomer we went to visit

442

00:17:19,429 --> 00:17:17,120

his radio telescope this back in brazil

443

00:17:21,750 --> 00:17:19,439

so i was exposed to some signs

444

00:17:24,309 --> 00:17:21,760

and i remember in high school saying

445

00:17:26,470 --> 00:17:24,319

some of the images of the virgo was

446

00:17:29,510 --> 00:17:26,480

standing from the outer planets and

447

00:17:31,029 --> 00:17:29,520

being awe and fast forward a couple of

448

00:17:33,590 --> 00:17:31,039

years later

449

00:17:36,070 --> 00:17:33,600

i accept the position

450

00:17:38,630 --> 00:17:36,080

in the jet propulsion lab to become a

451
00:17:41,430 --> 00:17:38,640
postdoc and i remember coming into the

452
00:17:43,430 --> 00:17:41,440
von kamen auditorium and seeing the size

453
00:17:45,909 --> 00:17:43,440
of voyager it's fill out the whole

454
00:17:48,789 --> 00:17:45,919
auditorium it's breathtaking and you can

455
00:17:52,150 --> 00:17:48,799
imagine this huge apparatus is a huge

456
00:17:53,669 --> 00:17:52,160
machine flying into space and and i was

457
00:17:56,070 --> 00:17:53,679
thinking oh my god i'm going to go back

458
00:17:57,430 --> 00:17:56,080
to my office and analyze data this

459
00:18:00,390 --> 00:17:57,440
incredible

460
00:18:01,750 --> 00:18:00,400
machine will be sending back so this was

461
00:18:03,430 --> 00:18:01,760
incredible

462
00:18:05,029 --> 00:18:03,440
and the other

463
00:18:06,310 --> 00:18:05,039

personal

464

00:18:08,390 --> 00:18:06,320

note here

465

00:18:10,549 --> 00:18:08,400

is i you know i was coming to space

466

00:18:13,590 --> 00:18:10,559

science from a different community so i

467

00:18:16,310 --> 00:18:13,600

was not really familiar with space

468

00:18:18,950 --> 00:18:16,320

mission with pis and i walk into the

469

00:18:21,590 --> 00:18:18,960

voyager team meeting first time and i

470

00:18:24,390 --> 00:18:21,600

see ed stone sitting at the head of the

471

00:18:26,150 --> 00:18:24,400

table all these scientists sitting there

472

00:18:28,549 --> 00:18:26,160

and i felt like i was coming to the

473

00:18:29,669 --> 00:18:28,559

enterprise ship from star trek i was

474

00:18:34,549 --> 00:18:29,679

like

475

00:18:36,230 --> 00:18:34,559

the team is being you can tell that

476
00:18:38,630 --> 00:18:36,240
they're being analyzing the data and

477
00:18:40,870 --> 00:18:38,640
discussing the signs for years

478
00:18:43,350 --> 00:18:40,880
they're much older than me and they're

479
00:18:46,150 --> 00:18:43,360
all guys i was the only woman coming so

480
00:18:48,950 --> 00:18:46,160
it was scary and so it took me a while

481
00:18:51,510 --> 00:18:48,960
until i found my own voice and i was

482
00:18:52,870 --> 00:18:51,520
have courage to contribute to the

483
00:18:54,870 --> 00:18:52,880
discussion

484
00:18:56,870 --> 00:18:54,880
but was also amazing to hear them

485
00:18:59,350 --> 00:18:56,880
discussing at that time they were

486
00:19:02,390 --> 00:18:59,360
arguing if we cross the termination

487
00:19:04,390 --> 00:19:02,400
shock and this is the boundary as ed was

488
00:19:07,110 --> 00:19:04,400

describing where the solar wind become

489

00:19:08,310 --> 00:19:07,120

very slow much slower than the sonic

490

00:19:10,870 --> 00:19:08,320

speed

491

00:19:13,430 --> 00:19:10,880

and there was looking at data and trying

492

00:19:16,390 --> 00:19:13,440

to say did we cross or not so it was

493

00:19:18,789 --> 00:19:16,400

mind-boggling for me to realize how the

494

00:19:20,630 --> 00:19:18,799

science you have to look very very

495

00:19:23,110 --> 00:19:20,640

carefully at this data it's a very

496

00:19:25,270 --> 00:19:23,120

precious data and before you know this

497

00:19:27,350 --> 00:19:25,280

is a legacy for the community of what we

498

00:19:29,110 --> 00:19:27,360

know about the solar system

499

00:19:32,549 --> 00:19:29,120

so we have to be really really careful

500

00:19:34,630 --> 00:19:32,559

of how to interpret this data so this is

501
00:19:37,350 --> 00:19:34,640
a great experience so let me tell you a

502
00:19:40,470 --> 00:19:37,360
little bit about the science and as ed

503
00:19:42,230 --> 00:19:40,480
mentioned earlier i think voyager wrote

504
00:19:43,750 --> 00:19:42,240
their books about what we know about

505
00:19:44,710 --> 00:19:43,760
outer planets

506
00:19:47,029 --> 00:19:44,720
and

507
00:19:49,669 --> 00:19:47,039
i think we all agree that is rewriting

508
00:19:51,590 --> 00:19:49,679
what we know about how stars interact

509
00:19:54,150 --> 00:19:51,600
with interstellar medium

510
00:19:56,310 --> 00:19:54,160
how it interact with

511
00:19:59,750 --> 00:19:56,320
the medius around them how their

512
00:20:02,310 --> 00:19:59,760
associates look like so it has lots of

513
00:20:03,830 --> 00:20:02,320

new discoveries and one of the first

514

00:20:06,950 --> 00:20:03,840

discovery

515

00:20:09,270 --> 00:20:06,960

let me show in the next image this came

516

00:20:12,310 --> 00:20:09,280

from simulations

517

00:20:15,590 --> 00:20:12,320

like the one i am used to do so this is

518

00:20:17,190 --> 00:20:15,600

like a side view of our heliosphere and

519

00:20:19,830 --> 00:20:17,200

it shows the magnitude of the

520

00:20:21,110 --> 00:20:19,840

interstellar magnetic field this is the

521

00:20:23,669 --> 00:20:21,120

invisible

522

00:20:25,190 --> 00:20:23,679

force that engulfs us the sun has its

523

00:20:28,070 --> 00:20:25,200

own magnetic field

524

00:20:31,110 --> 00:20:28,080

but i'm showing here in red the

525

00:20:32,470 --> 00:20:31,120

intensity of the magnetic field outside

526

00:20:34,950 --> 00:20:32,480

our home

527

00:20:37,029 --> 00:20:34,960

and maybe an analogy that give you how

528

00:20:39,990 --> 00:20:37,039

much this is incredible that we can

529

00:20:41,750 --> 00:20:40,000

sense what this magnetic field is doing

530

00:20:43,350 --> 00:20:41,760

you know sitting in your kitchen and

531

00:20:44,310 --> 00:20:43,360

you're measuring the weather outside

532

00:20:46,230 --> 00:20:44,320

your home

533

00:20:48,870 --> 00:20:46,240

and this is what we're doing we are with

534

00:20:51,750 --> 00:20:48,880

the voyagers in the helio shifts and we

535

00:20:54,070 --> 00:20:51,760

are able to sense enough from the data

536

00:20:55,669 --> 00:20:54,080

coming from voyager to tell that our

537

00:20:57,669 --> 00:20:55,679

home is distorted

538

00:20:59,750 --> 00:20:57,679

that the southern hemisphere is pushed

539

00:21:02,390 --> 00:20:59,760

in and you can see where your tourism in

540

00:21:04,070 --> 00:21:02,400

the south is much closer to the sun than

541

00:21:05,990 --> 00:21:04,080

the northern hemisphere so this was a

542

00:21:07,350 --> 00:21:06,000

major discovery

543

00:21:08,549 --> 00:21:07,360

the next

544

00:21:11,110 --> 00:21:08,559

image show

545

00:21:13,909 --> 00:21:11,120

if you would be in extraterrestrial

546

00:21:15,029 --> 00:21:13,919

heading towards our heliosphere what you

547

00:21:22,789 --> 00:21:15,039

will see

548

00:21:24,470 --> 00:21:22,799

smooth shape and it's sidewise

549

00:21:27,270 --> 00:21:24,480

so i like to think we're navigating

550

00:21:30,470 --> 00:21:27,280

through interstellar medium sidewise and

551
00:21:32,149 --> 00:21:30,480
this is again the effect of this force

552
00:21:35,029 --> 00:21:32,159
that i'm talking the magnetic field

553
00:21:36,950 --> 00:21:35,039
outside our home distorting us and you

554
00:21:39,190 --> 00:21:36,960
can see virgin one in red in the

555
00:21:40,549 --> 00:21:39,200
northern hemisphere and virgil two in

556
00:21:43,430 --> 00:21:40,559
the south

557
00:21:46,390 --> 00:21:43,440
and it's it's nice to see that not just

558
00:21:48,549 --> 00:21:46,400
voyager is saying that other missions

559
00:21:51,029 --> 00:21:48,559
um that are out there

560
00:21:53,510 --> 00:21:51,039
are seeing the same effect so voyager

561
00:21:55,990 --> 00:21:53,520
measure in situ we're smelling we're

562
00:21:58,230 --> 00:21:56,000
touching the ionized matter in the

563
00:22:00,950 --> 00:21:58,240

heliosheath but there is other missions

564

00:22:02,470 --> 00:22:00,960

like ibex and cassini please bring the

565

00:22:04,950 --> 00:22:02,480

next image

566

00:22:07,510 --> 00:22:04,960

that give us a map

567

00:22:09,510 --> 00:22:07,520

of what is out there so this is an image

568

00:22:12,390 --> 00:22:09,520

not like the previous one that is an

569

00:22:15,669 --> 00:22:12,400

image from outside looking back to our

570

00:22:18,789 --> 00:22:15,679

heliosphere this is an image from inside

571

00:22:21,510 --> 00:22:18,799

from earth looking out or from cassini

572

00:22:24,230 --> 00:22:21,520

from saturn looking out and mapping this

573

00:22:26,230 --> 00:22:24,240

energetic neutrals that come to us

574

00:22:28,149 --> 00:22:26,240

and without going all the details in

575

00:22:30,789 --> 00:22:28,159

that you can see that these bright

576

00:22:33,270 --> 00:22:30,799

features in ibex in the in the upper

577

00:22:34,390 --> 00:22:33,280

part and in casino in the lower the red

578

00:22:36,630 --> 00:22:34,400

feature

579

00:22:39,270 --> 00:22:36,640

see that this emissions these neutrals

580

00:22:41,669 --> 00:22:39,280

are not uniformly spread out there is

581

00:22:43,270 --> 00:22:41,679

something organized in the data and

582

00:22:44,789 --> 00:22:43,280

again we think this is interstellar

583

00:22:47,909 --> 00:22:44,799

magnetic field

584

00:22:49,510 --> 00:22:47,919

so this is all coming together it's all

585

00:22:51,750 --> 00:22:49,520

missions

586

00:22:55,029 --> 00:22:51,760

and what is exciting what we're heading

587

00:22:57,909 --> 00:22:55,039

for the future is not only well for the

588

00:22:59,110 --> 00:22:57,919

first time in this brand new media the

589

00:23:00,789 --> 00:22:59,120

heliosheath

590

00:23:02,789 --> 00:23:00,799

and we are discovering that is very

591

00:23:04,870 --> 00:23:02,799

different than what we thought

592

00:23:07,430 --> 00:23:04,880

the magnetic fields behave different the

593

00:23:09,190 --> 00:23:07,440

ionized matter behave different so we're

594

00:23:10,230 --> 00:23:09,200

still trying to uncover

595

00:23:12,710 --> 00:23:10,240

this

596

00:23:14,789 --> 00:23:12,720

and we are heading towards as ed was

597

00:23:17,029 --> 00:23:14,799

mentioning the heliopause we never

598

00:23:19,190 --> 00:23:17,039

crossed the boundary like that so we

599

00:23:21,590 --> 00:23:19,200

don't really know what to expect

600

00:23:23,990 --> 00:23:21,600

so we're all holding our seats that we

601
00:23:26,310 --> 00:23:24,000
would be able to say yes we crossed and

602
00:23:28,470 --> 00:23:26,320
not still pondering looking at the data

603
00:23:30,549 --> 00:23:28,480
did we cross we didn't cross

604
00:23:31,590 --> 00:23:30,559
so this is very exciting period for

605
00:23:34,630 --> 00:23:31,600
voyager

606
00:23:37,270 --> 00:23:34,640
and you can see in the next image

607
00:23:39,350 --> 00:23:37,280
the wise image of a bow shock it's a

608
00:23:41,510 --> 00:23:39,360
beautiful image from the dust around

609
00:23:43,510 --> 00:23:41,520
that map the bow shock

610
00:23:45,669 --> 00:23:43,520
but this is a remote image

611
00:23:48,470 --> 00:23:45,679
and voyager will bring us for the first

612
00:23:52,470 --> 00:23:48,480
time instead of measurement the smell

613
00:23:54,470 --> 00:23:52,480

the touch of what is an astro shift so

614

00:23:57,029 --> 00:23:54,480

pass now to end that will give you what

615

00:23:58,549 --> 00:23:57,039

the message that voyager had to give us

616

00:24:00,870 --> 00:23:58,559

thank you mora

617

00:24:02,390 --> 00:24:00,880

so a voyager mission is that

618

00:24:05,510 --> 00:24:02,400

intersection

619

00:24:07,669 --> 00:24:05,520

of exploration our first epical

620

00:24:09,669 --> 00:24:07,679

reconnaissance of the outer solar system

621

00:24:12,230 --> 00:24:09,679

our first close-up look

622

00:24:13,590 --> 00:24:12,240

at 60 new worlds

623

00:24:15,510 --> 00:24:13,600

it's also

624

00:24:17,990 --> 00:24:15,520

scientific research

625

00:24:18,950 --> 00:24:18,000

in in that it's telling us the actual

626
00:24:21,029 --> 00:24:18,960
shape

627
00:24:23,669 --> 00:24:21,039
of the solar system as we move through

628
00:24:25,110 --> 00:24:23,679
the galaxy and much more than that

629
00:24:26,470 --> 00:24:25,120
but it's also

630
00:24:29,029 --> 00:24:26,480
a cultural

631
00:24:33,029 --> 00:24:29,039
and emotional and even a spiritual

632
00:24:36,710 --> 00:24:33,039
artifact for the human species we are

633
00:24:39,350 --> 00:24:36,720
looking at the golden voyager record

634
00:24:42,549 --> 00:24:39,360
which contains

635
00:24:45,590 --> 00:24:42,559
some 27 pieces of music it's considered

636
00:24:47,630 --> 00:24:45,600
in fact the origin of that concept of

637
00:24:50,950 --> 00:24:47,640
world music

638
00:24:54,149 --> 00:24:50,960

116 pictures of what life on earth is

639

00:24:55,190 --> 00:24:54,159

like from our most beautiful buildings

640

00:24:57,430 --> 00:24:55,200

to

641

00:24:58,870 --> 00:24:57,440

human beings and the other

642

00:25:02,470 --> 00:24:58,880

creatures with which we share this

643

00:25:03,990 --> 00:25:02,480

planet greetings in some 50 languages

644

00:25:05,750 --> 00:25:04,000

including

645

00:25:06,870 --> 00:25:05,760

the beautiful songs of the humpback

646

00:25:09,110 --> 00:25:06,880

whales

647

00:25:11,029 --> 00:25:09,120

and five languages that are no longer

648

00:25:12,950 --> 00:25:11,039

spoken ancient languages with no

649

00:25:15,510 --> 00:25:12,960

speakers as well as the most populous

650

00:25:17,590 --> 00:25:15,520

languages spoken on earth today

651
00:25:20,390 --> 00:25:17,600
and there's a sound essay on it

652
00:25:22,310 --> 00:25:20,400
which includes a mother's first words to

653
00:25:24,390 --> 00:25:22,320
her newborn baby

654
00:25:26,230 --> 00:25:24,400
and a baby's first cry

655
00:25:29,669 --> 00:25:26,240
the brain waves

656
00:25:33,269 --> 00:25:29,679
of a woman newly fallen in love

657
00:25:37,190 --> 00:25:33,279
the sound of the geological history

658
00:25:39,669 --> 00:25:37,200
of the earth its biological evolution

659
00:25:42,710 --> 00:25:39,679
and our technology

660
00:25:44,870 --> 00:25:42,720
and our what was then our recording of

661
00:25:46,230 --> 00:25:44,880
the most distant object which was a

662
00:25:47,750 --> 00:25:46,240
pulsar

663
00:25:49,909 --> 00:25:47,760

and all of this

664

00:25:54,470 --> 00:25:49,919

is may have the next slide please

665

00:25:55,190 --> 00:25:54,480

is uh is encased in a golden cover

666

00:25:57,909 --> 00:25:55,200

in

667

00:26:00,149 --> 00:25:57,919

engraved with scientific hieroglyphics

668

00:26:02,310 --> 00:26:00,159

instructions for play to the putative

669

00:26:04,950 --> 00:26:02,320

extraterrestrials we imagine might

670

00:26:08,710 --> 00:26:04,960

intercept it one day and if you can see

671

00:26:11,110 --> 00:26:08,720

that that circle is the record itself

672

00:26:12,789 --> 00:26:11,120

with the stylus that we included for

673

00:26:15,430 --> 00:26:12,799

play you know

674

00:26:17,430 --> 00:26:15,440

this is the 1970s when people were

675

00:26:19,909 --> 00:26:17,440

listening to records and i'm

676

00:26:21,750 --> 00:26:19,919

i'm really excited about the fact that

677

00:26:25,750 --> 00:26:21,760

musicians and lovers of music are

678

00:26:28,710 --> 00:26:25,760

returning to records as being richer in

679

00:26:29,909 --> 00:26:28,720

sound and information than digital

680

00:26:32,149 --> 00:26:29,919

recording

681

00:26:33,830 --> 00:26:32,159

and there's also a

682

00:26:36,390 --> 00:26:33,840

an atomic clock

683

00:26:38,310 --> 00:26:36,400

which will date when

684

00:26:40,950 --> 00:26:38,320

the record was launched and when the

685

00:26:45,430 --> 00:26:40,960

message was sent and then our address in

686

00:26:47,430 --> 00:26:45,440

the galaxy the 16 closest pulsars

687

00:26:48,710 --> 00:26:47,440

just to give a little sense of where

688

00:26:50,390 --> 00:26:48,720

this came from

689

00:26:51,269 --> 00:26:50,400

now i'd like you to listen

690

00:26:53,590 --> 00:26:51,279

to

691

00:26:56,149 --> 00:26:53,600

some of the sounds and some of the music

692

00:26:58,630 --> 00:26:56,159

included on voyager these are only tiny

693

00:27:01,430 --> 00:26:58,640

snippets of a much longer

694

00:27:03,510 --> 00:27:01,440

uh voyager message as well as to see

695

00:27:06,390 --> 00:27:03,520

just a handful of the images

696

00:27:08,070 --> 00:27:06,400

that are included on voyager and i ask

697

00:27:10,149 --> 00:27:08,080

you to imagine yourself an

698

00:27:12,470 --> 00:27:10,159

extraterrestrial

699

00:27:14,789 --> 00:27:12,480

who knows nothing of our planet and

700

00:27:15,830 --> 00:27:14,799

who's getting a first glimpse

701
00:27:16,710 --> 00:27:15,840
of

702
00:27:21,510 --> 00:27:16,720
what

703
00:27:27,840 --> 00:27:21,520
like thank you let's please play it

704
00:27:27,850 --> 00:27:35,510
[Music]

705
00:27:49,090 --> 00:27:37,230
aah

706
00:27:57,940 --> 00:27:57,470
[Music]

707
00:28:02,070 --> 00:27:57,950
[Applause]

708
00:28:30,470 --> 00:28:02,080
[Music]

709
00:28:30,480 --> 00:28:40,820
easy

710
00:29:03,510 --> 00:28:50,390
[Music]

711
00:29:07,430 --> 00:29:05,510
that gives you just some idea

712
00:29:09,669 --> 00:29:07,440
of the voyager record

713
00:29:12,310 --> 00:29:09,679

you know it was

714

00:29:13,750 --> 00:29:12,320

originally the idea of carl sagan and

715

00:29:15,669 --> 00:29:13,760

frank drake

716

00:29:17,990 --> 00:29:15,679

to send this message

717

00:29:20,630 --> 00:29:18,000

because of this gravitational assist

718

00:29:22,630 --> 00:29:20,640

from the massive planet jupiter the two

719

00:29:24,070 --> 00:29:22,640

voyager spacecraft were flung out of the

720

00:29:27,190 --> 00:29:24,080

solar system

721

00:29:28,470 --> 00:29:27,200

and are expected to

722

00:29:30,870 --> 00:29:28,480

wander at

723

00:29:32,389 --> 00:29:30,880

speeds of something like 40 000 miles an

724

00:29:33,990 --> 00:29:32,399

hour through

725

00:29:36,630 --> 00:29:34,000

interstellar space

726
00:29:37,750 --> 00:29:36,640
for a thousand million years

727
00:29:40,630 --> 00:29:37,760
and

728
00:29:42,149 --> 00:29:40,640
the geniuses who designed the mission

729
00:29:44,230 --> 00:29:42,159
trajectories

730
00:29:46,630 --> 00:29:44,240
so that these two spacecraft could

731
00:29:49,350 --> 00:29:46,640
rendezvous with these planets and moons

732
00:29:51,669 --> 00:29:49,360
and flawlessly you have to send back to

733
00:29:55,350 --> 00:29:51,679
us these images

734
00:29:57,669 --> 00:29:55,360
of the outer solar system and

735
00:29:58,789 --> 00:29:57,679
the idea that this spacecraft is still

736
00:30:00,870 --> 00:29:58,799
functioning

737
00:30:03,190 --> 00:30:00,880
that a young person in the audience

738
00:30:04,549 --> 00:30:03,200

today a child in this audience

739

00:30:05,750 --> 00:30:04,559

it's possible they could come to

740

00:30:08,070 --> 00:30:05,760

maturity

741

00:30:10,230 --> 00:30:08,080

and become a scientist or

742

00:30:11,510 --> 00:30:10,240

a technician or a mathematician or an

743

00:30:13,669 --> 00:30:11,520

engineer

744

00:30:16,230 --> 00:30:13,679

and the voyagers will still

745

00:30:18,870 --> 00:30:16,240

still be thriving this is the result of

746

00:30:21,269 --> 00:30:18,880

the genius of nasa and i'd like to show

747

00:30:24,149 --> 00:30:21,279

a few pictures of the men and women who

748

00:30:27,190 --> 00:30:24,159

were involved in the voyager mission

749

00:30:30,630 --> 00:30:27,200

in those days it was largely men and i'm

750

00:30:32,870 --> 00:30:30,640

happy to point to the shift in the ratio

751

00:30:34,389 --> 00:30:32,880

here on the panel today

752

00:30:36,470 --> 00:30:34,399

but these guys

753

00:30:38,950 --> 00:30:36,480

you know they did something that is

754

00:30:41,350 --> 00:30:38,960

absolutely the equal of magellan or

755

00:30:44,870 --> 00:30:41,360

columbus or any of the great

756

00:30:48,149 --> 00:30:44,880

explorers of terrestrial discovery

757

00:30:51,750 --> 00:30:48,159

and yet um how many of us know the name

758

00:30:53,909 --> 00:30:51,760

charlie cole hayes or gary flandro or

759

00:30:55,830 --> 00:30:53,919

michael minovich these guys should be on

760

00:30:58,870 --> 00:30:55,840

the stand because

761

00:31:00,950 --> 00:30:58,880

you know if we don't if we don't value

762

00:31:03,909 --> 00:31:00,960

the genius behind

763

00:31:06,149 --> 00:31:03,919

taking a building a machine with 1970s

764

00:31:07,509 --> 00:31:06,159

technology you know virtually out of

765

00:31:08,470 --> 00:31:07,519

transistors

766

00:31:10,710 --> 00:31:08,480

to

767

00:31:11,830 --> 00:31:10,720

that one that functions so brilliantly

768

00:31:12,630 --> 00:31:11,840

today

769

00:31:15,269 --> 00:31:12,640

and

770

00:31:16,070 --> 00:31:15,279

uh to be able to do this exploring for

771

00:31:18,549 --> 00:31:16,080

us

772

00:31:20,870 --> 00:31:18,559

if we don't value their contribution

773

00:31:23,350 --> 00:31:20,880

then is it any wonder that so few of our

774

00:31:25,669 --> 00:31:23,360

children are really interested in doing

775

00:31:27,430 --> 00:31:25,679

what they did

776

00:31:30,070 --> 00:31:27,440

so i just wanted to

777

00:31:33,669 --> 00:31:30,080

say what an amazing contribution

778

00:31:34,549 --> 00:31:33,679

to our civilization and the fact

779

00:31:37,110 --> 00:31:34,559

that

780

00:31:39,029 --> 00:31:37,120

perhaps a hundred million years ago or

781

00:31:40,870 --> 00:31:39,039

500 million years ago

782

00:31:43,590 --> 00:31:40,880

voyager's greatest

783

00:31:46,870 --> 00:31:43,600

triumph is yet to come

784

00:31:49,909 --> 00:31:46,880

it will sing for us and speak for us

785

00:31:52,310 --> 00:31:49,919

long after the very continents of our

786

00:31:54,470 --> 00:31:52,320

planet have changed

787

00:31:57,350 --> 00:31:54,480

that's an ethical achievement

788

00:31:59,590 --> 00:31:57,360

and i think when people ask you know

789

00:32:01,269 --> 00:31:59,600

why spend money on space exploration

790

00:32:03,830 --> 00:32:01,279

when we have so many problems here well

791

00:32:05,110 --> 00:32:03,840

that's a perfectly good question

792

00:32:07,430 --> 00:32:05,120

but

793

00:32:11,269 --> 00:32:07,440

i think we have to do both things and i

794

00:32:14,070 --> 00:32:11,279

think that the voyager has deceived it

795

00:32:18,149 --> 00:32:14,080

exceeded its design specifications

796

00:32:18,950 --> 00:32:18,159

and the loftiest dreams of its makers

797

00:32:20,070 --> 00:32:18,960

and

798

00:32:21,590 --> 00:32:20,080

i'd like to

799

00:32:24,630 --> 00:32:21,600

go back to the

800

00:32:26,710 --> 00:32:24,640

the family portrait of our solar system

801
00:32:28,950 --> 00:32:26,720
and to talk about the maturity of our

802
00:32:29,909 --> 00:32:28,960
species that we are now in a position to

803
00:32:33,830 --> 00:32:29,919
look

804
00:32:37,750 --> 00:32:33,840
at the other worlds of our solar system

805
00:32:40,070 --> 00:32:37,760
only 400 years after galileo's first

806
00:32:43,029 --> 00:32:40,080
look through a telescope this is the

807
00:32:47,430 --> 00:32:43,039
awesome power of the scientific method

808
00:32:50,310 --> 00:32:47,440
and looking at that family portrait

809
00:32:52,070 --> 00:32:50,320
i'm reminded of the fact that carl sagan

810
00:32:54,389 --> 00:32:52,080
who was a member of the voyager imaging

811
00:32:55,750 --> 00:32:54,399
team and very much involved in the

812
00:32:58,149 --> 00:32:55,760
project

813
00:32:59,669 --> 00:32:58,159

he asked that voyager's

814

00:33:00,470 --> 00:32:59,679

cameras

815

00:33:03,110 --> 00:33:00,480

be

816

00:33:05,190 --> 00:33:03,120

turned to look homeward one last time

817

00:33:06,950 --> 00:33:05,200

before they were taken

818

00:33:09,350 --> 00:33:06,960

before they were turned off

819

00:33:12,950 --> 00:33:09,360

to take one last picture and he was

820

00:33:16,470 --> 00:33:12,960

largely responsible for urging nasa to

821

00:33:18,710 --> 00:33:16,480

take this image of our world

822

00:33:20,230 --> 00:33:18,720

not the apollo

823

00:33:23,430 --> 00:33:20,240

frame-filling

824

00:33:25,830 --> 00:33:23,440

world which in itself was a major

825

00:33:27,909 --> 00:33:25,840

paradigm shift for our culture and

826

00:33:30,070 --> 00:33:27,919

civilization globally

827

00:33:32,389 --> 00:33:30,080

but now to see us

828

00:33:34,389 --> 00:33:32,399

in something that reflects more clearly

829

00:33:36,230 --> 00:33:34,399

our true circumstances

830

00:33:39,350 --> 00:33:36,240

in the cosmos

831

00:33:42,710 --> 00:33:39,360

that pale blue dot in that circle

832

00:33:43,909 --> 00:33:42,720

and i'd like to close this phase of our

833

00:33:46,389 --> 00:33:43,919

talk

834

00:33:48,230 --> 00:33:46,399

with the words of carl sagan

835

00:33:51,509 --> 00:33:48,240

in his meditation

836

00:33:56,870 --> 00:33:51,519

on that image and what it could mean for

837

00:34:00,950 --> 00:33:59,430

consider again that dot

838

00:34:02,470 --> 00:34:00,960

that's here

839

00:34:04,310 --> 00:34:02,480

that's home

840

00:34:05,509 --> 00:34:04,320

that's us

841

00:34:07,269 --> 00:34:05,519

on it

842

00:34:09,190 --> 00:34:07,279

everyone you love

843

00:34:11,909 --> 00:34:09,200

everyone you know

844

00:34:13,829 --> 00:34:11,919

everyone you ever heard of every human

845

00:34:17,109 --> 00:34:13,839

being who ever was

846

00:34:21,030 --> 00:34:18,230

the earth

847

00:34:24,869 --> 00:34:21,040

is a very small stage

848

00:34:27,909 --> 00:34:24,879

in a vast cosmic arena

849

00:34:30,389 --> 00:34:27,919

think of the rivers of blood spilled by

850

00:34:32,710 --> 00:34:30,399

all those generals and emperors so that

851
00:34:35,190 --> 00:34:32,720
in glory and triumph they could become

852
00:34:36,790 --> 00:34:35,200
the momentary masters

853
00:34:39,030 --> 00:34:36,800
of a fraction

854
00:34:41,990 --> 00:34:39,040
of a dot

855
00:34:44,149 --> 00:34:42,000
think of the endless cruelties visited

856
00:34:45,349 --> 00:34:44,159
by the inhabitants of one corner of this

857
00:34:47,270 --> 00:34:45,359
pixel

858
00:34:48,710 --> 00:34:47,280
on the scarcely distinguishable

859
00:34:50,470 --> 00:34:48,720
inhabitants

860
00:34:53,430 --> 00:34:50,480
of some other corner

861
00:34:56,310 --> 00:34:53,440
how frequent their misunderstandings

862
00:35:00,310 --> 00:34:56,320
how eager they are to kill one another

863
00:35:04,870 --> 00:35:02,390

there is perhaps no better demonstration

864

00:35:07,190 --> 00:35:04,880

of the folly of human conceits

865

00:35:09,510 --> 00:35:07,200

than this distant image

866

00:35:10,470 --> 00:35:09,520

of our tiny world

867

00:35:12,870 --> 00:35:10,480

to me

868

00:35:15,829 --> 00:35:12,880

it underscores our responsibility to

869

00:35:17,190 --> 00:35:15,839

deal more kindly with one another and to

870

00:35:18,390 --> 00:35:17,200

preserve

871

00:35:20,230 --> 00:35:18,400

and cherish

872

00:35:21,750 --> 00:35:20,240

the pale blue dot

873

00:35:32,310 --> 00:35:21,760

the only home

874

00:35:35,510 --> 00:35:33,670

something to think about ladies and

875

00:35:38,390 --> 00:35:35,520

gentlemen

876
00:35:40,310 --> 00:35:38,400
we're as profound then as they are still

877
00:35:42,790 --> 00:35:40,320
now

878
00:35:44,870 --> 00:35:42,800
before we open it up for questions i

879
00:35:46,710 --> 00:35:44,880
would like to

880
00:35:47,990 --> 00:35:46,720
inform folks that deep space missions

881
00:35:50,230 --> 00:35:48,000
like this

882
00:35:52,710 --> 00:35:50,240
are enabled by a very unique power

883
00:35:56,069 --> 00:35:52,720
source called a radio isotope

884
00:35:59,270 --> 00:35:56,079
thermoelectric generator

885
00:36:00,710 --> 00:35:59,280
it in essence essentially a nuclear

886
00:36:03,030 --> 00:36:00,720
battery

887
00:36:04,950 --> 00:36:03,040
that enables incredible missions like

888
00:36:07,589 --> 00:36:04,960

this and for more information on this

889

00:36:10,710 --> 00:36:07,599

incredible power source very safe

890

00:36:12,390 --> 00:36:10,720

and clearly very reliable

891

00:36:15,390 --> 00:36:12,400

as a result of the amazing story here

892

00:36:16,950 --> 00:36:15,400

and other missions for 50 years go to

893

00:36:18,390 --> 00:36:16,960

www.nasa.gov

894

00:36:20,390 --> 00:36:18,400

and learn more about this incredible

895

00:36:27,190 --> 00:36:20,400

power source

896

00:36:28,710 --> 00:36:27,200

going to mars in another version

897

00:36:31,270 --> 00:36:28,720

advanced version

898

00:36:34,470 --> 00:36:31,280

mars science laboratory or curiosity

899

00:36:37,589 --> 00:36:36,069

now

900

00:36:38,790 --> 00:36:37,599

we are going to do something different

901
00:36:41,589 --> 00:36:38,800
here

902
00:36:42,790 --> 00:36:41,599
we have a national audience viewing this

903
00:36:44,790 --> 00:36:42,800
program

904
00:36:48,390 --> 00:36:44,800
and in that national audience on

905
00:36:50,230 --> 00:36:48,400
numerous students in schools

906
00:36:52,150 --> 00:36:50,240
and this is what we are about ladies and

907
00:36:53,910 --> 00:36:52,160
gentlemen this is what these amazing

908
00:36:55,750 --> 00:36:53,920
people are about so we're going to take

909
00:36:56,630 --> 00:36:55,760
questions from these schools which we

910
00:36:58,630 --> 00:36:56,640
have

911
00:37:01,430 --> 00:36:58,640
we received

912
00:37:03,829 --> 00:37:01,440
many many and for the schools listening

913
00:37:05,109 --> 00:37:03,839

you can still send in your questions the

914

00:37:07,430 --> 00:37:05,119

the wonderful folks at the jet

915

00:37:08,950 --> 00:37:07,440

propulsion lab in the education outreach

916

00:37:11,950 --> 00:37:08,960

department will answer your questions to

917

00:37:14,470 --> 00:37:11,960

post answers on the web at

918

00:37:16,310 --> 00:37:14,480

www.nasa.gov slash voyager but we're

919

00:37:18,710 --> 00:37:16,320

going to take a trip around

920

00:37:20,310 --> 00:37:18,720

the nation here with the schools who are

921

00:37:23,030 --> 00:37:20,320

here because this is what it's about

922

00:37:25,030 --> 00:37:23,040

inspiration

923

00:37:27,990 --> 00:37:25,040

we're going to go to

924

00:37:28,870 --> 00:37:28,000

columbia south carolina

925

00:37:31,670 --> 00:37:28,880

and

926

00:37:34,790 --> 00:37:31,680

this is a question for you suzanne from

927

00:37:36,390 --> 00:37:34,800

miss carboni seventh and eighth grade

928

00:37:40,069 --> 00:37:36,400

math classes

929

00:37:42,790 --> 00:37:41,430

what have we learned from gorgeous

930

00:37:44,630 --> 00:37:42,800

technology

931

00:37:49,190 --> 00:37:44,640

that is being applied to current and

932

00:37:54,470 --> 00:37:51,670

oh okay thank you duane um

933

00:37:57,109 --> 00:37:54,480

so there i think are many technology

934

00:37:59,190 --> 00:37:57,119

firsts that the voyager pioneered that

935

00:38:02,390 --> 00:37:59,200

were used by follow-on missions since

936

00:38:05,030 --> 00:38:02,400

has such as a galileo mission to jupiter

937

00:38:06,790 --> 00:38:05,040

and the cassini mission to saturn

938

00:38:09,109 --> 00:38:06,800

i'm going to highlight just a couple of

939

00:38:10,710 --> 00:38:09,119

them for you here

940

00:38:11,829 --> 00:38:10,720

when the pioneer spacecraft went by

941

00:38:14,069 --> 00:38:11,839

jupiter

942

00:38:16,069 --> 00:38:14,079

ahead of voyager

943

00:38:18,390 --> 00:38:16,079

they discovered a very strong radiation

944

00:38:19,750 --> 00:38:18,400

field and that got the engineers at jpl

945

00:38:21,750 --> 00:38:19,760

thinking we've got to do something

946

00:38:24,390 --> 00:38:21,760

different for voyager or we won't

947

00:38:27,829 --> 00:38:24,400

survive the flyby of jupiter

948

00:38:29,109 --> 00:38:27,839

so the engineers at jpl came up with a

949

00:38:32,310 --> 00:38:29,119

the

950

00:38:34,630 --> 00:38:32,320

technique of using radiation harden

951
00:38:36,310 --> 00:38:34,640
electronic parts and what you're doing

952
00:38:38,390 --> 00:38:36,320
here is that you're

953
00:38:40,630 --> 00:38:38,400
shielding and screening the electronics

954
00:38:42,230 --> 00:38:40,640
so those high energy charge particles

955
00:38:43,829 --> 00:38:42,240
can't damage them

956
00:38:45,030 --> 00:38:43,839
so that was one technique that's been

957
00:38:46,710 --> 00:38:45,040
used on

958
00:38:48,310 --> 00:38:46,720
practically every spacecraft sit there

959
00:38:49,589 --> 00:38:48,320
since then certainly every spacecraft

960
00:38:52,150 --> 00:38:49,599
was going to

961
00:38:55,109 --> 00:38:52,160
a jupiter or a mission with some place

962
00:38:57,910 --> 00:38:55,119
where there's a high radiation field

963
00:39:00,630 --> 00:38:57,920

and i think another great

964

00:39:03,910 --> 00:39:00,640

first for voyager was the use of

965

00:39:05,510 --> 00:39:03,920

a programmable command processor

966

00:39:07,990 --> 00:39:05,520

the voyager mission today wouldn't be

967

00:39:10,790 --> 00:39:08,000

what it was without the ability to

968

00:39:12,230 --> 00:39:10,800

change the commanding of voyager has it

969

00:39:13,750 --> 00:39:12,240

got further out

970

00:39:14,710 --> 00:39:13,760

the longer distance planets and then

971

00:39:16,790 --> 00:39:14,720

into

972

00:39:18,950 --> 00:39:16,800

the voyager interstellar mission and you

973

00:39:20,230 --> 00:39:18,960

will not see a spacecraft today that

974

00:39:23,349 --> 00:39:20,240

doesn't fly

975

00:39:25,990 --> 00:39:23,359

uh without a commandable uh processor

976
00:39:28,790 --> 00:39:26,000
and that was developed first for voyager

977
00:39:31,109 --> 00:39:28,800
and a little antidote that's similarly

978
00:39:34,550 --> 00:39:31,119
related to that voyager is flying with

979
00:39:36,310 --> 00:39:34,560
only 68 kilobytes of memory between

980
00:39:41,670 --> 00:39:36,320
three

981
00:39:43,589 --> 00:39:41,680
walk home and take the subway home or

982
00:39:46,390 --> 00:39:43,599
your school kids are uh you put on your

983
00:39:48,790 --> 00:39:46,400
earphones and you turn up your ipad or

984
00:39:51,349 --> 00:39:48,800
excuse me your ipod nano i want you to

985
00:39:53,589 --> 00:39:51,359
think about that has eight gigabytes or

986
00:39:55,510 --> 00:39:53,599
yeah eight gigabytes of memory so it's

987
00:39:58,069 --> 00:39:55,520
got a hundred thousand times more memory

988
00:39:59,750 --> 00:39:58,079

in your ipod than it does in the voyager

989

00:40:01,670 --> 00:39:59,760

spacecraft so i like to use that

990

00:40:03,589 --> 00:40:01,680

antidote a lot to

991

00:40:05,349 --> 00:40:03,599

to relate to how technology changes

992

00:40:06,630 --> 00:40:05,359

rapidly

993

00:40:08,630 --> 00:40:06,640

thanks to that

994

00:40:11,510 --> 00:40:08,640

moravia up next from

995

00:40:13,750 --> 00:40:11,520

mrs laura jek

996

00:40:16,230 --> 00:40:13,760

seventh graders homeschool program in

997

00:40:18,630 --> 00:40:16,240

the morgan hill unified district in san

998

00:40:20,710 --> 00:40:18,640

jose california

999

00:40:22,710 --> 00:40:20,720

please discuss one two three of the most

1000

00:40:24,390 --> 00:40:22,720

important changes

1001
00:40:27,589 --> 00:40:24,400
about our understanding of the

1002
00:40:30,069 --> 00:40:27,599
heliosphere and interactions with fluff

1003
00:40:32,950 --> 00:40:30,079
that must be changed or updated

1004
00:40:36,390 --> 00:40:32,960
as a result of gorgeous discoveries

1005
00:40:38,309 --> 00:40:36,400
thank you duane um well some i already

1006
00:40:40,630 --> 00:40:38,319
kind of discussed when i was talking

1007
00:40:43,030 --> 00:40:40,640
about the science discoveries

1008
00:40:45,589 --> 00:40:43,040
one major one was the fact that our

1009
00:40:47,270 --> 00:40:45,599
heliosphere is asymmetric that is pushed

1010
00:40:49,829 --> 00:40:47,280
in in the south

1011
00:40:52,630 --> 00:40:49,839
rather than in the in bulging out in the

1012
00:40:55,510 --> 00:40:52,640
north this is one major discovery the

1013
00:40:58,309 --> 00:40:55,520

other one is that the magnetic field

1014

00:41:00,390 --> 00:40:58,319

this invisible force that lies in the

1015

00:41:01,109 --> 00:41:00,400

interstellar medium the medium ahead of

1016

00:41:02,870 --> 00:41:01,119

us

1017

00:41:04,550 --> 00:41:02,880

has an orientation

1018

00:41:06,630 --> 00:41:04,560

that this is what our measurements are

1019

00:41:09,190 --> 00:41:06,640

telling us that is not in the same

1020

00:41:10,550 --> 00:41:09,200

direction as the milky way the disk of

1021

00:41:12,470 --> 00:41:10,560

our galaxy

1022

00:41:15,430 --> 00:41:12,480

that this is the field in really large

1023

00:41:17,750 --> 00:41:15,440

scales so something happened between

1024

00:41:20,230 --> 00:41:17,760

really big scales where the stars are

1025

00:41:22,309 --> 00:41:20,240

until getting closer home the weather

1026

00:41:25,190 --> 00:41:22,319

change we don't know why

1027

00:41:28,230 --> 00:41:25,200

if what make we have some ideas

1028

00:41:31,589 --> 00:41:28,240

but there is a different orientation and

1029

00:41:34,069 --> 00:41:31,599

it has a strength that is pretty strong

1030

00:41:37,430 --> 00:41:34,079

so it's my it has some implications that

1031

00:41:39,750 --> 00:41:37,440

it might be a dominant energy outside

1032

00:41:41,270 --> 00:41:39,760

our home we don't know

1033

00:41:42,630 --> 00:41:41,280

there's another

1034

00:41:45,190 --> 00:41:42,640

discovery

1035

00:41:48,069 --> 00:41:45,200

harder to explain but one of the

1036

00:41:50,550 --> 00:41:48,079

interesting things that when voyager

1037

00:41:53,910 --> 00:41:50,560

2 crossed the termination shock the

1038

00:41:55,430 --> 00:41:53,920

region where the solar wind is very slow

1039

00:41:58,150 --> 00:41:55,440

the temperature

1040

00:42:00,150 --> 00:41:58,160

of the heliostats was much lower was an

1041

00:42:01,510 --> 00:42:00,160

order of magnitude lower than what we

1042

00:42:04,390 --> 00:42:01,520

expected

1043

00:42:05,349 --> 00:42:04,400

and voyager measure the thermal ionized

1044

00:42:07,910 --> 00:42:05,359

matter

1045

00:42:09,990 --> 00:42:07,920

so this energy went somewhere else and

1046

00:42:12,710 --> 00:42:10,000

we think it went to what we call

1047

00:42:16,550 --> 00:42:12,720

suprathermal particles very energetic

1048

00:42:19,349 --> 00:42:16,560

particles so it's just make us think how

1049

00:42:21,270 --> 00:42:19,359

fluids how ionized goes through shocks

1050

00:42:22,550 --> 00:42:21,280

we have to think about it where the

1051
00:42:24,390 --> 00:42:22,560
energy goes

1052
00:42:25,990 --> 00:42:24,400
so this was

1053
00:42:28,069 --> 00:42:26,000
thank you

1054
00:42:30,790 --> 00:42:28,079
okay now we're going to kettering ohio

1055
00:42:34,230 --> 00:42:30,800
van buren middle school and this is for

1056
00:42:36,390 --> 00:42:34,240
you uh susan again suzanne uh mr doe and

1057
00:42:39,670 --> 00:42:36,400
mr lowell's eighth grade

1058
00:42:41,190 --> 00:42:39,680
cyber science and science classes

1059
00:42:43,109 --> 00:42:41,200
we read an article on the voyager

1060
00:42:44,950 --> 00:42:43,119
website that says voyager 1's plasma

1061
00:42:45,750 --> 00:42:44,960
instrument was broken

1062
00:42:49,109 --> 00:42:45,760
but

1063
00:42:50,630 --> 00:42:49,119

the one on voyager 2 was working fine

1064

00:42:52,309 --> 00:42:50,640

how did nasa know that the plasma

1065

00:42:54,470 --> 00:42:52,319

instrument of origin 2

1066

00:42:56,550 --> 00:42:54,480

was working properly suzanne thanks

1067

00:42:58,870 --> 00:42:56,560

wayne well the plasma instrument

1068

00:43:00,069 --> 00:42:58,880

measures the lowest energy charged

1069

00:43:02,710 --> 00:43:00,079

particles

1070

00:43:04,069 --> 00:43:02,720

in the solar wind and it measures both

1071

00:43:07,030 --> 00:43:04,079

the speed and the direction of those

1072

00:43:08,470 --> 00:43:07,040

particles now when voyager 1 went past

1073

00:43:10,470 --> 00:43:08,480

saturn

1074

00:43:12,630 --> 00:43:10,480

there was a failure with the high

1075

00:43:13,670 --> 00:43:12,640

voltage modulator on the plasma

1076

00:43:22,069 --> 00:43:13,680

instrument

1077

00:43:23,910 --> 00:43:22,079

incapable of getting any significant

1078

00:43:27,190 --> 00:43:23,920

data back

1079

00:43:29,270 --> 00:43:27,200

now voyager 2 uh the plasma instrument

1080

00:43:31,270 --> 00:43:29,280

is still operating we're still taking

1081

00:43:33,990 --> 00:43:31,280

data with it

1082

00:43:36,950 --> 00:43:34,000

when we get that data back we analyze it

1083

00:43:40,710 --> 00:43:36,960

and we compare it to

1084

00:43:43,270 --> 00:43:40,720

from other spacecraft

1085

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

and because those tend to match up we

1086

00:43:46,230 --> 00:43:45,440

believe that the data we're getting back

1087

00:43:48,309 --> 00:43:46,240

from

1088

00:43:50,309 --> 00:43:48,319

the plasma instrument is

1089

00:43:53,829 --> 00:43:50,319

accurate and that the instrument is

1090

00:43:55,670 --> 00:43:53,839

functioning properly on voyager

1091

00:43:57,750 --> 00:43:55,680

thank you

1092

00:43:59,829 --> 00:43:57,760

and a question for you

1093

00:44:01,430 --> 00:43:59,839

this comes from union

1094

00:44:02,309 --> 00:44:01,440

new jersey

1095

00:44:03,430 --> 00:44:02,319

mr

1096

00:44:05,589 --> 00:44:03,440

petrus

1097

00:44:06,550 --> 00:44:05,599

sixth eighth grade gifted and talented

1098

00:44:10,069 --> 00:44:06,560

students

1099

00:44:12,470 --> 00:44:10,079

from the union middle school

1100

00:44:13,910 --> 00:44:12,480

what made astronomers astronomers decide

1101
00:44:15,270 --> 00:44:13,920
to record the things they did on the

1102
00:44:17,109 --> 00:44:15,280
golden disc

1103
00:44:21,109 --> 00:44:17,119
what makes astronomers think that their

1104
00:44:22,870 --> 00:44:21,119
directions were straightforward enough

1105
00:44:23,829 --> 00:44:22,880
for these creatures to listen to the

1106
00:44:26,790 --> 00:44:23,839
disc

1107
00:44:29,829 --> 00:44:26,800
or understand the image

1108
00:44:31,270 --> 00:44:29,839
these are really two great questions

1109
00:44:34,470 --> 00:44:31,280
let me take the one about the

1110
00:44:37,990 --> 00:44:34,480
instructions for play and our cosmic

1111
00:44:42,710 --> 00:44:40,390
even though voyager has a very long

1112
00:44:45,190 --> 00:44:42,720
future as described earlier perhaps a

1113
00:44:47,750 --> 00:44:45,200

thousand million years

1114

00:44:48,630 --> 00:44:47,760

wherever it goes in that area the laws

1115

00:44:50,950 --> 00:44:48,640

of

1116

00:44:52,790 --> 00:44:50,960

physics will be the same

1117

00:44:55,790 --> 00:44:52,800

and that's the only common language that

1118

00:44:57,750 --> 00:44:55,800

we can hope to have with these imagined

1119

00:45:01,109 --> 00:44:57,760

extraterrestrials remember we have yet

1120

00:45:04,309 --> 00:45:01,119

to receive any evidence that they exist

1121

00:45:06,309 --> 00:45:04,319

but we look at the enormity the vastness

1122

00:45:09,030 --> 00:45:06,319

of the universe and the number of worlds

1123

00:45:12,069 --> 00:45:09,040

and the processes that led to the

1124

00:45:13,829 --> 00:45:12,079

the origin of life on earth and we

1125

00:45:15,829 --> 00:45:13,839

we suspect they may be out there but

1126

00:45:18,870 --> 00:45:15,839

that's different from knowing

1127

00:45:21,190 --> 00:45:18,880

but if they are out there the only way

1128

00:45:24,390 --> 00:45:21,200

that the voyager record is going to be

1129

00:45:26,950 --> 00:45:24,400

intercepted because space is so mostly

1130

00:45:29,349 --> 00:45:26,960

empty the emptiness of space cannot be

1131

00:45:31,430 --> 00:45:29,359

exaggerated so we're not imagining that

1132

00:45:33,270 --> 00:45:31,440

one of these spacecraft will collide

1133

00:45:35,670 --> 00:45:33,280

with the world and

1134

00:45:38,710 --> 00:45:35,680

someone will on that world will find the

1135

00:45:41,510 --> 00:45:38,720

record we're imagining that space-faring

1136

00:45:43,349 --> 00:45:41,520

extraterrestrials will flag it down

1137

00:45:44,829 --> 00:45:43,359

now if you're smart enough

1138

00:45:48,069 --> 00:45:44,839

to travel in

1139

00:45:50,390 --> 00:45:48,079

space then we'd like to bet that you're

1140

00:45:51,829 --> 00:45:50,400

smart enough to figure out what we're

1141

00:45:54,710 --> 00:45:51,839

trying to say

1142

00:45:56,710 --> 00:45:54,720

in the hieroglyphics so that was the

1143

00:45:58,950 --> 00:45:56,720

reasoning behind it

1144

00:46:00,550 --> 00:45:58,960

and the second part of the question is

1145

00:46:02,630 --> 00:46:00,560

why you know how did we choose this and

1146

00:46:05,030 --> 00:46:02,640

it wasn't just astronomers it was

1147

00:46:06,309 --> 00:46:05,040

artists writers

1148

00:46:08,950 --> 00:46:06,319

musicians

1149

00:46:11,750 --> 00:46:08,960

ethno musicologists people who study the

1150

00:46:15,510 --> 00:46:11,760

the history of music there are many many

1151

00:46:18,470 --> 00:46:15,520

people involved and we decided

1152

00:46:20,870 --> 00:46:18,480

to go for a complete picture

1153

00:46:22,870 --> 00:46:20,880

of our planet and so

1154

00:46:25,270 --> 00:46:22,880

we wanted to represent all of the

1155

00:46:27,750 --> 00:46:25,280

world's great musical traditions

1156

00:46:29,750 --> 00:46:27,760

we didn't want it just to be from our

1157

00:46:31,270 --> 00:46:29,760

american point of view

1158

00:46:33,510 --> 00:46:31,280

we wanted to show

1159

00:46:35,670 --> 00:46:33,520

really a planetary perspective and

1160

00:46:37,430 --> 00:46:35,680

that's what science and astronomy and

1161

00:46:38,790 --> 00:46:37,440

missions like voyager

1162

00:46:41,829 --> 00:46:38,800

do they

1163

00:46:42,870 --> 00:46:41,839

make you think in terms of your planet

1164

00:46:44,150 --> 00:46:42,880

and so

1165

00:46:46,950 --> 00:46:44,160

every piece

1166

00:46:50,390 --> 00:46:46,960

could be considered a kind of a a tile

1167

00:46:53,910 --> 00:46:50,400

in a much greater mosaic so we have a 12

1168

00:46:55,430 --> 00:46:53,920

year old child singing and we have a 95

1169

00:46:59,030 --> 00:46:55,440

year old

1170

00:47:01,910 --> 00:46:59,040

virtuoso on the chinese chin a stringed

1171

00:47:05,109 --> 00:47:01,920

instrument playing one of the pieces

1172

00:47:07,990 --> 00:47:05,119

we have images of day at night young and

1173

00:47:09,430 --> 00:47:08,000

old everything was trying to

1174

00:47:12,390 --> 00:47:09,440

was was

1175

00:47:15,270 --> 00:47:12,400

chosen so not just for its intrinsic

1176

00:47:18,230 --> 00:47:15,280

value but for its ability to fill in

1177

00:47:20,710 --> 00:47:18,240

another blank in the puzzle of what life

1178

00:47:21,670 --> 00:47:20,720

on earth is like

1179

00:47:22,710 --> 00:47:21,680

thank you

1180

00:47:24,230 --> 00:47:22,720

we're going to use the remaining time

1181

00:47:27,030 --> 00:47:24,240

for just two more questions and i want

1182

00:47:28,790 --> 00:47:27,040

to remind all of the students out there

1183

00:47:30,790 --> 00:47:28,800

in the nation and across the world that

1184

00:47:32,710 --> 00:47:30,800

you can still send in your questions at

1185

00:47:34,549 --> 00:47:32,720

nasa.gov slash voyager and your

1186

00:47:36,390 --> 00:47:34,559

questions will be posted and we'll get

1187

00:47:38,470 --> 00:47:36,400

your answers as quickly as possible so

1188

00:47:40,630 --> 00:47:38,480

keep those questions coming in ed we're

1189

00:47:42,710 --> 00:47:40,640

coming back to you

1190

00:47:44,230 --> 00:47:42,720

this is from northwest arkansas

1191

00:47:47,109 --> 00:47:44,240

community college

1192

00:47:49,349 --> 00:47:47,119

dixie andrews college course survey of

1193

00:47:50,950 --> 00:47:49,359

the universe

1194

00:47:52,549 --> 00:47:50,960

do we anticipate

1195

00:47:54,710 --> 00:47:52,559

seeing higher concentrations of charged

1196

00:47:57,589 --> 00:47:54,720

particles from interstellar space in the

1197

00:47:59,190 --> 00:47:57,599

outer region of the heliopause perimeter

1198

00:48:00,790 --> 00:47:59,200

if yes why

1199

00:48:02,549 --> 00:48:00,800

if no why not

1200

00:48:05,910 --> 00:48:02,559

well that's a wonderful question it

1201

00:48:08,069 --> 00:48:05,920

turns out that inside the solar bubble

1202

00:48:09,990 --> 00:48:08,079

the magnetic field comes from our sun

1203

00:48:12,069 --> 00:48:10,000

just like the solar wind comes from our

1204

00:48:13,349 --> 00:48:12,079

sun the solar wind carries it out

1205

00:48:15,270 --> 00:48:13,359

outside

1206

00:48:16,950 --> 00:48:15,280

the wind comes from these other stars

1207

00:48:19,910 --> 00:48:16,960

that blew up and the magnetic field

1208

00:48:21,670 --> 00:48:19,920

comes from those other stars and in fact

1209

00:48:23,910 --> 00:48:21,680

though because the magnetic field is

1210

00:48:26,870 --> 00:48:23,920

different inside and outside the ions

1211

00:48:28,870 --> 00:48:26,880

outside cannot easily get inside and

1212

00:48:30,230 --> 00:48:28,880

those inside can't easily get outside

1213

00:48:31,829 --> 00:48:30,240

that's the reason all the solar wind

1214

00:48:34,230 --> 00:48:31,839

goes down the tail

1215

00:48:36,069 --> 00:48:34,240

now at the boundary itself there is

1216

00:48:38,390 --> 00:48:36,079

probably some turbulence and we are

1217

00:48:41,030 --> 00:48:38,400

starting to talk about what we expect to

1218

00:48:43,190 --> 00:48:41,040

see because it's unlike it's unlikely

1219

00:48:45,030 --> 00:48:43,200

that we understand exactly how this

1220

00:48:47,829 --> 00:48:45,040

interface is between these different

1221

00:48:50,069 --> 00:48:47,839

winds and i suspect like in the past we

1222

00:48:52,309 --> 00:48:50,079

will be surprised and we may in fact

1223

00:48:54,309 --> 00:48:52,319

have a debate for a year or two before

1224

00:48:56,790 --> 00:48:54,319

we finally decide we have crossed the

1225

00:48:58,710 --> 00:48:56,800

boundary

1226

00:49:00,390 --> 00:48:58,720

okay our last question and this is

1227

00:49:04,150 --> 00:49:00,400

definitely from a rob because we're

1228

00:49:09,750 --> 00:49:07,270

denise selmo high school english teacher

1229

00:49:11,030 --> 00:49:09,760

santa maria in sarao paulo tell me about

1230

00:49:12,630 --> 00:49:11,040

that right yeah

1231

00:49:14,470 --> 00:49:12,640

is it possible that some of the

1232

00:49:17,349 --> 00:49:14,480

particles detected by georgia can carry

1233

00:49:19,589 --> 00:49:17,359

information about some kind of life

1234

00:49:23,750 --> 00:49:19,599

out of our solar system

1235

00:49:28,870 --> 00:49:26,710

but so what voyager detects is not

1236

00:49:31,829 --> 00:49:28,880

molecule so it cannot really detect

1237

00:49:34,710 --> 00:49:31,839

directly any signatures of life out

1238

00:49:37,030 --> 00:49:34,720

there but it detects atoms and atoms are

1239

00:49:38,549 --> 00:49:37,040

the building blocks of life so we are

1240

00:49:40,309 --> 00:49:38,559

inferring

1241

00:49:42,630 --> 00:49:40,319

what you call abundances so you're

1242

00:49:44,710 --> 00:49:42,640

inferring how much atoms of each type

1243

00:49:47,589 --> 00:49:44,720

are out there once we cross the

1244

00:49:51,109 --> 00:49:47,599

interstellar medium we will learn also

1245

00:49:53,589 --> 00:49:51,119

what lies be outside of solar system and

1246

00:49:54,630 --> 00:49:53,599

this is the building blocks of life

1247

00:49:56,829 --> 00:49:54,640

so

1248

00:49:59,270 --> 00:49:56,839

indirectly we will learn

1249

00:50:00,950 --> 00:49:59,280

great well we're gonna we're gonna wrap

1250

00:50:02,870 --> 00:50:00,960

it wrap it up here what i would like to

1251
00:50:04,390 --> 00:50:02,880
do i would be remiss that when we do

1252
00:50:06,390 --> 00:50:04,400
incredible and amazing missions like

1253
00:50:09,030 --> 00:50:06,400
this we don't do it alone and i talked

1254
00:50:09,750 --> 00:50:09,040
about the the power source the rtg and

1255
00:50:11,990 --> 00:50:09,760
the

1256
00:50:14,150 --> 00:50:12,000
version that will be on mars science lab

1257
00:50:16,309 --> 00:50:14,160
these are built by the department of

1258
00:50:18,309 --> 00:50:16,319
energy so it is an incredible

1259
00:50:21,190 --> 00:50:18,319
relationship we have when we do deep

1260
00:50:23,190 --> 00:50:21,200
space missions it's a partnership

1261
00:50:24,630 --> 00:50:23,200
and it works very well

1262
00:50:26,390 --> 00:50:24,640
i want to thank

1263
00:50:37,510 --> 00:50:26,400

these amazing folks may we please give

1264

00:50:43,030 --> 00:50:40,870

amazing story by amazing people

1265

00:50:45,349 --> 00:50:43,040

and you guys are amazing nasa and