



Science discovers that
the rings of Saturn are
actually lost airline luggage.



1
00:00:18,120 --> 00:00:08,589
again welcome to Griffith Observatory my

2
00:00:24,580 --> 00:00:22,150
so thank you and welcome you know I've

3
00:00:26,769 --> 00:00:24,590
got low feet back here first I just want

4
00:00:29,499 --> 00:00:26,779
to ask how many of you are members of

5
00:00:31,600 --> 00:00:29,509
the Cassini team are scientists with

6
00:00:33,910 --> 00:00:31,610
Cassini so look around we've got a lot

7
00:00:42,640 --> 00:00:33,920
of scientists here and I think if

8
00:00:44,439 --> 00:00:42,650
there's anybody observes around you our

9
00:00:46,689 --> 00:00:44,449
regulars for all space considered our

10
00:00:49,240 --> 00:00:46,699
Friday night oh we love you so much

11
00:00:52,420 --> 00:00:49,250
thank you for coming back how many of

12
00:00:54,009 --> 00:00:52,430
you are total members and we really love

13
00:00:56,619 --> 00:00:54,019

you so if you want to be really loved

14

00:00:59,560 --> 00:00:56,629

join Friends of the observatory which is

15

00:01:01,960 --> 00:00:59,570

our our our membership organization

16

00:01:03,910 --> 00:01:01,970

which also helps underwrite so many of

17

00:01:06,340 --> 00:01:03,920

our expenses for our program our school

18

00:01:08,440 --> 00:01:06,350

program for all the little children how

19

00:01:10,810 --> 00:01:08,450

can you resist we hope that you will

20

00:01:21,600 --> 00:01:10,820

consider becoming a fun member how about

21

00:01:26,290 --> 00:01:24,760

you don't know this is run by the city

22

00:01:29,800 --> 00:01:26,300

of Los Angeles Department of Recreation

23

00:01:31,570 --> 00:01:29,810

parks and you know no mom cities have a

24

00:01:34,600 --> 00:01:31,580

free beautiful observatory life

25

00:01:37,480 --> 00:01:34,610

observatory to come too so thank you tax

26
00:01:40,360 --> 00:01:37,490
payers then I thank you photo Thank You

27
00:01:43,660 --> 00:01:40,370
Cassini T and the rest of you well we're

28
00:01:45,010 --> 00:01:43,670
glad you're here too ah so anyway I've

29
00:01:46,510 --> 00:01:45,020
already taken up many minutes in the

30
00:01:48,430 --> 00:01:46,520
introduction that I really should just

31
00:01:50,530 --> 00:01:48,440
jump right to the program because we

32
00:01:53,080 --> 00:01:50,540
have such an exciting program tonight it

33
00:01:55,690 --> 00:01:53,090
made me so sad to limit the panel to

34
00:01:58,210 --> 00:01:55,700
just you know a few minutes each go

35
00:01:59,530 --> 00:01:58,220
through because there frankly we could

36
00:02:02,200 --> 00:01:59,540
have a whole evening with each and every

37
00:02:04,300 --> 00:02:02,210
one of these individuals and still be

38
00:02:08,020 --> 00:02:04,310

wanting more there's just been so much

39

00:02:10,719 --> 00:02:08,030
excitement and wonderful science coming

40

00:02:12,460 --> 00:02:10,729
from the Cassini mission so tonight

41

00:02:14,320 --> 00:02:12,470
we're going to get just to hear a little

42

00:02:16,449 --> 00:02:14,330
bit of an overview they happen to be

43

00:02:17,410 --> 00:02:16,459
having their science team meeting at JPL

44

00:02:24,760 --> 00:02:17,420
and

45

00:02:26,410 --> 00:02:24,770
them here I want to make a few kind of

46

00:02:28,449 --> 00:02:26,420
housekeeping announcements and then

47

00:02:30,640 --> 00:02:28,459
introduced our panel and then get out of

48

00:02:33,850 --> 00:02:30,650
the way so you can hear about about the

49

00:02:35,559 --> 00:02:33,860
Cassini mission first announcement is if

50

00:02:37,870 --> 00:02:35,569
you have a cell phone turn it off

51
00:02:40,360 --> 00:02:37,880
the second is if you must leave during

52
00:02:42,910 --> 00:02:40,370
the program please exit out the back I

53
00:02:44,770 --> 00:02:42,920
know this says exit and it is an exit

54
00:02:47,140 --> 00:02:44,780
but it really is only for emergencies

55
00:02:49,120 --> 00:02:47,150
because it goes to this crazy little

56
00:02:53,320 --> 00:02:49,130
place back here that you will get lost

57
00:02:55,990 --> 00:02:53,330
and scared so if we have an emergency we

58
00:03:00,160 --> 00:02:56,000
will lead you out but if you need to

59
00:03:02,979 --> 00:03:00,170
leave back doors are your exit let me

60
00:03:04,660 --> 00:03:02,989
also say that we have a harpist one of

61
00:03:06,190 --> 00:03:04,670
the Cassini team members plays the harp

62
00:03:08,229 --> 00:03:06,200
and she played on the West Terrace today

63
00:03:15,520 --> 00:03:08,239

so if you're here Janet we thank you it

64

00:03:17,110 --> 00:03:15,530

was lovely program but we didn't want to

65

00:03:18,520 --> 00:03:17,120

leave it up on the church so here it is

66

00:03:21,550 --> 00:03:18,530

if you're wondering why there's a harp

67

00:03:24,190 --> 00:03:21,560

and lastly this is being videotaped and

68

00:03:27,340 --> 00:03:24,200

will probably be streamed on the Cassini

69

00:03:29,770 --> 00:03:27,350

team Facebook site so if you don't like

70

00:03:33,670 --> 00:03:29,780

your face to be seen you know just do

71

00:03:35,770 --> 00:03:33,680

this on the camera but you may come in

72

00:03:38,199 --> 00:03:35,780

here you've consented to be taped and

73

00:03:40,840 --> 00:03:38,209

possibly broadcast or webcast on them on

74

00:03:43,330 --> 00:03:40,850

the web so just let you know that we

75

00:03:46,810 --> 00:03:43,340

make sure that your consent is all right

76

00:03:48,819 --> 00:03:46,820

so um I think I am ready to move with

77

00:03:50,530 --> 00:03:48,829

the introductions and so if I kind of

78

00:03:53,050 --> 00:03:50,540

ask our panel to come up and you have a

79

00:03:55,390 --> 00:03:53,060

seat this is my chair so you can take

80

00:03:57,370 --> 00:03:55,400

those five and I will start with the

81

00:03:59,199 --> 00:03:57,380

introductions and this is so

82

00:04:00,789 --> 00:03:59,209

embarrassing because no HOF to all look

83

00:04:04,809 --> 00:04:00,799

at their pictures because I got them off

84

00:04:06,250 --> 00:04:04,819

the web our first panelist is Kevin

85

00:04:09,069 --> 00:04:06,260

Bane's who is at Jet Propulsion

86

00:04:11,199 --> 00:04:09,079

Laboratory and has been there since 1984

87

00:04:13,240 --> 00:04:11,209

first as a research scientist and now as

88

00:04:15,599 --> 00:04:13,250

a principal scientist he's worked on

89

00:04:18,460 --> 00:04:15,609

many different missions Venus Express

90

00:04:20,409 --> 00:04:18,470

Galileo and he's the Venus Earth Jupiter

91

00:04:21,550 --> 00:04:20,419

atmospheric science coordinator I

92

00:04:25,000 --> 00:04:21,560

thought that was on like such an

93

00:04:26,420 --> 00:04:25,010

intriguing title he's now of course with

94

00:04:29,240 --> 00:04:26,430

the Cassini mission he's going to be

95

00:04:30,980 --> 00:04:29,250

telling us all about the actual planet

96

00:04:32,270 --> 00:04:30,990

we can't forget about Saturn with all

97

00:04:33,800 --> 00:04:32,280

they were saying are though those rings

98

00:04:36,350 --> 00:04:33,810

and moons they get all the glory but

99

00:04:39,529 --> 00:04:36,360

Saturn is the real has all the gravitas

100

00:04:41,270 --> 00:04:39,539

as we said and this is a real show in

101
00:04:43,760 --> 00:04:41,280
town please any telling us about that he

102
00:04:46,580 --> 00:04:43,770
got his PhD in physics from Washington

103
00:04:48,950 --> 00:04:46,590
University wendice filter is our next

104
00:04:50,840 --> 00:04:48,960
speaker and she's done she's the deputy

105
00:04:53,240 --> 00:04:50,850
project scientist for Cassini she's been

106
00:04:56,480 --> 00:04:53,250
with a mission since nineteen that's a

107
00:05:01,610 --> 00:04:56,490
1980 oh is that my hand right 1990 I

108
00:05:08,480 --> 00:05:01,620
can't read my own writing 1990 uh-oh

109
00:05:11,600 --> 00:05:08,490
yes madam ha ha ha Wow and and is before

110
00:05:14,960 --> 00:05:11,610
that worked on Voyager and as both in

111
00:05:16,760 --> 00:05:14,970
infrared and also photo polarimetry and

112
00:05:21,620 --> 00:05:16,770
she got her PhD from right here in

113
00:05:22,730 --> 00:05:21,630

Southern California UCLA and we're happy

114

00:05:24,200 --> 00:05:22,740

to have her here she's here to talk

115

00:05:27,920 --> 00:05:24,210

about brain maybe someone who had seen

116

00:05:30,980 --> 00:05:27,930

her on TV she'd I've seen her lovely job

117

00:05:34,610 --> 00:05:30,990

Tallis at gumball see who is our the

118

00:05:36,589 --> 00:05:34,620

magnetic or the magnetosphere scientist

119

00:05:38,390 --> 00:05:36,599

he is the Rollins cursed soccer

120

00:05:40,610 --> 00:05:38,400

professor of engineering University of

121

00:05:42,230 --> 00:05:40,620

Michigan and the chairman of the

122

00:05:44,300 --> 00:05:42,240

atmospheric Oceanic and Space Sciences

123

00:05:46,430 --> 00:05:44,310

Department he's the director of the

124

00:05:48,230 --> 00:05:46,440

center for space environment modeling

125

00:05:50,779 --> 00:05:48,240

and I understand just learned who's been

126

00:05:52,510 --> 00:05:50,789

working with other planetary ins to do

127

00:05:56,210 --> 00:05:52,520

some beautiful visualizations for

128

00:05:59,480 --> 00:05:56,220

planetarium shows his his Hungarian by

129

00:06:01,189 --> 00:05:59,490

birth and actually worked with the wants

130

00:06:02,210 --> 00:06:01,199

a Panera as opposed to Ventura but I

131

00:06:05,659 --> 00:06:02,220

actually don't know the proper

132

00:06:07,879 --> 00:06:05,669

pronunciation better venue then there

133

00:06:09,710 --> 00:06:07,889

you go which is some of you may remember

134

00:06:12,469 --> 00:06:09,720

the Soviet Union's

135

00:06:15,439 --> 00:06:12,479

missions in the mid 70s to Venus

136

00:06:17,149 --> 00:06:15,449

actually landed on Venus and so he's

137

00:06:19,399 --> 00:06:17,159

been doing long space research for a

138

00:06:20,839 --> 00:06:19,409

long time he's a member of the

139

00:06:23,120 --> 00:06:20,849

International Academy of astronautics

140

00:06:25,689 --> 00:06:23,130

hello the American Geophysical Union

141

00:06:29,330 --> 00:06:25,699

been an editor on many different

142

00:06:31,370 --> 00:06:29,340

scientific journals and a long long list

143

00:06:32,689 --> 00:06:31,380

of awards and service and we're just

144

00:06:42,670 --> 00:06:32,699

thrilled to have him Harry's going to be

145

00:06:51,830 --> 00:06:48,500

one of those gassy planets uh then next

146

00:06:55,700 --> 00:06:51,840

is Amanda Hendricks who is also a JPL

147

00:06:57,890 --> 00:06:55,710

and has been there since or been part of

148

00:07:02,540 --> 00:06:57,900

the team team since 1999 if I'm correct

149

00:07:04,520 --> 00:07:02,550

ah and has got her PhD from University

150

00:07:08,750 --> 00:07:04,530

of Colorado and was a postdoc there as

151

00:07:11,090 --> 00:07:08,760

well she's also involved in many future

152

00:07:12,500 --> 00:07:11,100

oh gosh and skipped over Ray's future

153

00:07:14,120 --> 00:07:12,510

involvements everybody's involved in new

154

00:07:15,920 --> 00:07:14,130

projects after Cassini so I'm going to

155

00:07:19,400 --> 00:07:15,930

have to just get that since I didn't do

156

00:07:22,880 --> 00:07:19,410

it for everyone but she is a

157

00:07:25,490 --> 00:07:22,890

co-investigator for with the ultraviolet

158

00:07:27,440 --> 00:07:25,500

imaging system and the Galileo

159

00:07:32,860 --> 00:07:27,450

ultraviolet spectrometer experiment on

160

00:07:34,940 --> 00:07:32,870

Galileo and she's going to My heavens

161

00:07:36,710 --> 00:07:34,950

forgotten what you're talking about like

162

00:07:38,330 --> 00:07:36,720

satellites good boy how could I forget

163

00:07:41,060 --> 00:07:38,340

enhance those moons I've lacked enough

164

00:07:42,650 --> 00:07:41,070

oh I shouldn't say that satellites have

165

00:07:44,840 --> 00:07:42,660

been getting so much wonderful wonderful

166

00:07:47,510 --> 00:07:44,850

press very exciting and lastly John

167

00:07:49,670 --> 00:07:47,520

Living Jonathan Levine who is professor

168

00:07:51,500 --> 00:07:49,680

of planetary science and physics at the

169

00:07:53,510 --> 00:07:51,510

University of Arizona is a distinguished

170

00:07:54,680 --> 00:07:53,520

visiting scientist at NASA's Jet

171

00:07:55,940 --> 00:07:54,690

Propulsion Laboratory where he's a

172

00:07:57,770 --> 00:07:55,950

member of the director's Advisory

173

00:07:59,570 --> 00:07:57,780

Council he's an interdisciplinary

174

00:08:02,300 --> 00:07:59,580

science on the Cassini mission to Saturn

175

00:08:03,980 --> 00:08:02,310

and an interdisciplinary scientist for

176
00:08:05,990 --> 00:08:03,990
the James Webb telescope which is the

177
00:08:08,659 --> 00:08:06,000
Hubble telescope follow-on he's also

178
00:08:11,480 --> 00:08:08,669
involved with the Juno mission concept

179
00:08:13,340 --> 00:08:11,490
under development and he got his PhD

180
00:08:15,020 --> 00:08:13,350
also here in Southern California at

181
00:08:16,909 --> 00:08:15,030
Caltech and he's an author of many

182
00:08:20,090 --> 00:08:16,919
popular books and fellow of the American

183
00:08:21,980 --> 00:08:20,100
geophysical union and again the list of

184
00:08:24,250 --> 00:08:21,990
honors and awards and chairmanships and

185
00:08:28,219 --> 00:08:24,260
service goes on so we have an incredibly

186
00:08:30,590 --> 00:08:28,229
distinguished panel here today about 12

187
00:08:33,380 --> 00:08:30,600
years ago the Cassini satellite was

188
00:08:37,010 --> 00:08:33,390

launched to Saturn not Jupiter but

189

00:08:42,290 --> 00:08:37,020

Saturn now in 2004 seven-hour seven

190

00:08:44,810 --> 00:08:42,300

hours later seven years later I went or

191

00:08:46,009 --> 00:08:44,820

and I just I just will say on a personal

192

00:08:47,930 --> 00:08:46,019

note I remember that happening because

193

00:08:50,000 --> 00:08:47,940

there was a prediction of when Cassini

194

00:08:51,920 --> 00:08:50,010

should go into orbit and I think it went

195

00:08:53,720 --> 00:08:51,930

or within less than 10 seconds like

196

00:08:57,380 --> 00:08:53,730

three seconds of the predicted time the

197

00:08:59,840 --> 00:08:57,390

engineering was so right on that you

198

00:09:01,970 --> 00:08:59,850

know it gives us some kind of sense that

199

00:09:03,680 --> 00:09:01,980

in fact we know what we're doing and you

200

00:09:06,259 --> 00:09:03,690

know what we're talking about in science

201
00:09:08,690 --> 00:09:06,269
is a very productive way to understand

202
00:09:12,530 --> 00:09:08,700
the universe and interact with it so

203
00:09:14,300 --> 00:09:12,540
it's been there since 2004 and has now

204
00:09:16,040 --> 00:09:14,310
moved into its extended mission and the

205
00:09:17,150 --> 00:09:16,050
equinox mission as they called I'm sure

206
00:09:21,050 --> 00:09:17,160
we'll hear a little bit more about that

207
00:09:23,329 --> 00:09:21,060
and I think that is really all say by

208
00:09:24,650 --> 00:09:23,339
way of introduction so that I can we can

209
00:09:27,079 --> 00:09:24,660
bring everybody up to the same level

210
00:09:29,150 --> 00:09:27,089
we're so glad you're here and with that

211
00:09:33,949 --> 00:09:29,160
I think I will turn this over to you

212
00:09:36,759 --> 00:09:33,959
Kevin and thank you very much you and

213
00:09:41,090 --> 00:09:36,769

the audience have to watch our our

214

00:09:42,949 --> 00:09:41,100

changeover procedures well great well

215

00:09:44,690 --> 00:09:42,959

thanks a lot for having us here really

216

00:09:46,389 --> 00:09:44,700

appreciate this that's my first time

217

00:09:48,170 --> 00:09:46,399

back at this in this area since it was

218

00:09:49,699 --> 00:09:48,180

redesigned I guess the rebuilt looks

219

00:09:51,230 --> 00:09:49,709

really beautiful here I have a lot to

220

00:09:53,600 --> 00:09:51,240

talk about we've done a lot of things at

221

00:09:55,400 --> 00:09:53,610

Saturn since being everett Koop up for

222

00:09:58,810 --> 00:09:55,410

four years now and it's no longer your

223

00:10:01,550 --> 00:09:58,820

father's Saturn it's a whole new center

224

00:10:03,190 --> 00:10:01,560

so you why it is now this is a typical

225

00:10:06,230 --> 00:10:03,200

picture of Saturn here that you've seen

226

00:10:07,760 --> 00:10:06,240

Boyer doing other types of imagers what

227

00:10:09,380 --> 00:10:07,770

we've done this mission is we've got a

228

00:10:11,120 --> 00:10:09,390

number of new instruments that seem

229

00:10:14,090 --> 00:10:11,130

different wavelength ranges so you see

230

00:10:16,310 --> 00:10:14,100

Saturn and a whole new light and reveals

231

00:10:18,590 --> 00:10:16,320

the depths of Saturn as well as things

232

00:10:20,360 --> 00:10:18,600

really high up lacor better than before

233

00:10:22,069 --> 00:10:20,370

so I'll show you that here's a little

234

00:10:23,900 --> 00:10:22,079

tutorial really quick on Jupiter Saturn

235

00:10:26,990 --> 00:10:23,910

Uranus Neptune those are the largest

236

00:10:29,090 --> 00:10:27,000

planets out there so the gas giants

237

00:10:31,220 --> 00:10:29,100

mostly comprised of hydrogen and helium

238

00:10:34,220 --> 00:10:31,230

which is the most abundant materials in

239

00:10:35,269 --> 00:10:34,230

the universe so expect them to be the

240

00:10:36,470 --> 00:10:35,279

most abundant things in the biggest

241

00:10:38,420 --> 00:10:36,480

planets indeed they are

242

00:10:40,430 --> 00:10:38,430

and there's Saturn just a sort of a

243

00:10:43,009 --> 00:10:40,440

little brother of Jupiter but almost the

244

00:10:44,160 --> 00:10:43,019

same size but then down below you've got

245

00:10:45,240 --> 00:10:44,170

earth so if you want to

246

00:10:47,370 --> 00:10:45,250

who thinks of scale there's a little

247

00:10:48,510 --> 00:10:47,380

earth and there's Saturn and Jupiter so

248

00:10:51,630 --> 00:10:48,520

those are really the Lords of the solar

249

00:10:53,220 --> 00:10:51,640

system and but you know all along

250

00:10:55,410 --> 00:10:53,230

supid has gotten most of the credit for

251
00:10:57,960 --> 00:10:55,420
being a dynamic place we've got the the

252
00:10:59,700 --> 00:10:57,970
the red spot here in the lots of storm

253
00:11:01,770 --> 00:10:59,710
system a Jupiter here's poor Saturn not

254
00:11:03,870 --> 00:11:01,780
for camp F are we looking here it is hit

255
00:11:06,390 --> 00:11:03,880
to as a more recent image in the visible

256
00:11:08,430 --> 00:11:06,400
it looks not too exciting and here's a

257
00:11:10,380 --> 00:11:08,440
picture taken a couple years ago with

258
00:11:11,790 --> 00:11:10,390
the visual camera and certainly within a

259
00:11:13,620 --> 00:11:11,800
few seconds of this make your depth

260
00:11:15,420 --> 00:11:13,630
being taken we took another picture in

261
00:11:16,860 --> 00:11:15,430
any ever read and this is what we saw so

262
00:11:17,700 --> 00:11:16,870
you see a whole different perspective to

263
00:11:19,440 --> 00:11:17,710

the planet

264

00:11:22,080 --> 00:11:19,450

lots of features out here were talks

265

00:11:23,610 --> 00:11:22,090

plane in a second and you see a very

266

00:11:24,450 --> 00:11:23,620

building between this Hemisphere and

267

00:11:26,420 --> 00:11:24,460

northern hemisphere the southern

268

00:11:28,350 --> 00:11:26,430

hemisphere tells you a lot of

269

00:11:30,300 --> 00:11:28,360

hemispherical and see some things going

270

00:11:32,250 --> 00:11:30,310

on but all these features in here are

271

00:11:33,780 --> 00:11:32,260

really deep in the atmosphere and most

272

00:11:35,790 --> 00:11:33,790

of us never conceive a more solid show

273

00:11:38,670 --> 00:11:35,800

use highlights of that really quick as

274

00:11:40,710 --> 00:11:38,680

we can prolong here I just think this

275

00:11:42,960 --> 00:11:40,720

pipeline was going on right here is at a

276

00:11:44,610 --> 00:11:42,970

waypoint of five microns that's about

277

00:11:46,440 --> 00:11:44,620

eight times the wavelength you can see

278

00:11:47,970 --> 00:11:46,450

so it's only where heats heat is so

279

00:11:50,820 --> 00:11:47,980

you're looking at the thermal heat of

280

00:11:52,710 --> 00:11:50,830

the planet this planet is so is so deep

281

00:11:54,630 --> 00:11:52,720

that as you go down into the atmosphere

282

00:11:56,010 --> 00:11:54,640

it warms up just like me coming up a

283

00:11:58,200 --> 00:11:56,020

mountain or from different airplane own

284

00:11:59,250 --> 00:11:58,210

differ surfaces earth it gets hotter and

285

00:11:59,610 --> 00:11:59,260

hotter and hotter as you go down to the

286

00:12:01,590 --> 00:11:59,620

surface

287

00:12:03,390 --> 00:12:01,600

if you go down into Saturn deep enough

288

00:12:04,620 --> 00:12:03,400

it gets to be room temperature and then

289

00:12:06,360 --> 00:12:04,630

it gets to be even hotter and you can

290

00:12:08,220 --> 00:12:06,370

get up to several thousand degrees so

291

00:12:09,570 --> 00:12:08,230

there's a glow to the planet and this is

292

00:12:11,760 --> 00:12:09,580

being blocked this close being blocked

293

00:12:14,100 --> 00:12:11,770

by these clouds so in here like black

294

00:12:16,020 --> 00:12:14,110

smudges are clouds in silhouette

295

00:12:17,970 --> 00:12:16,030

basically and these clouds have big

296

00:12:20,520 --> 00:12:17,980

particles with them bigger than the park

297

00:12:21,660 --> 00:12:20,530

as we see up above up here and so we're

298

00:12:23,910 --> 00:12:21,670

seeing a whole different regime of the

299

00:12:24,870 --> 00:12:23,920

planet with this device at five microns

300

00:12:27,690 --> 00:12:24,880

is called the bim's

301
00:12:29,040 --> 00:12:27,700
instrument visual and fred nettinger so

302
00:12:30,960 --> 00:12:29,050
this has allowed us to see deep in the

303
00:12:33,330 --> 00:12:30,970
atmosphere here's a sunlight here you

304
00:12:35,760 --> 00:12:33,340
can see this one's coming over here and

305
00:12:37,350 --> 00:12:35,770
you see very high back here you see it's

306
00:12:40,170 --> 00:12:37,360
night so you don't see it but the gloves

307
00:12:41,730 --> 00:12:40,180
still work so the red thread aspect of

308
00:12:43,260 --> 00:12:41,740
it still comes through day or night so

309
00:12:44,730 --> 00:12:43,270
this technique which allows us to see

310
00:12:46,380 --> 00:12:44,740
deep in the atmosphere allows us to see

311
00:12:48,300 --> 00:12:46,390
both day and night anytime so it's kind

312
00:12:49,980 --> 00:12:48,310
of kind of cool thing to do so explain

313
00:12:52,800 --> 00:12:49,990

that here's some features now there's a

314

00:12:54,480 --> 00:12:52,810

typical visual view of typical type of

315

00:12:55,350 --> 00:12:54,490

high clouds here that we see here's a

316

00:12:57,509 --> 00:12:55,360

ring by the way is there

317

00:13:01,860 --> 00:12:57,519

rings as atmosphere scientists like the

318

00:13:04,110 --> 00:13:01,870

series Johnson and here we have the high

319

00:13:05,550 --> 00:13:04,120

clouds and now a revelation of five

320

00:13:07,110 --> 00:13:05,560

microns there will flex these little

321

00:13:08,940 --> 00:13:07,120

black clouds here blocking the light

322

00:13:10,560 --> 00:13:08,950

these features are very unique we

323

00:13:12,240 --> 00:13:10,570

haven't seen those before and is there a

324

00:13:13,259 --> 00:13:12,250

connection between here and here we

325

00:13:14,759 --> 00:13:13,269

think there are these we're following

326

00:13:17,040 --> 00:13:14,769

these plumes if you think those are

327

00:13:18,990 --> 00:13:17,050

updrafts and to collaborate that we've

328

00:13:20,880 --> 00:13:19,000

also got right our images we've got this

329

00:13:21,780 --> 00:13:20,890

radar which we never had before and we

330

00:13:23,910 --> 00:13:21,790

don't use radars

331

00:13:25,650 --> 00:13:23,920

as the usual standard we soon as the

332

00:13:27,329 --> 00:13:25,660

radar off we don't pay anything we just

333

00:13:28,380 --> 00:13:27,339

let it sit there passively and we're

334

00:13:30,329 --> 00:13:28,390

looking into two centimeter wave

335

00:13:31,980 --> 00:13:30,339

radiations about one inch long

336

00:13:33,690 --> 00:13:31,990

radiation coming coming out of the

337

00:13:35,970 --> 00:13:33,700

planet and it so happens that ammonia

338

00:13:38,130 --> 00:13:35,980

gas absorbs that radiation so if you see

339

00:13:39,449 --> 00:13:38,140

any variability like you do along here

340

00:13:42,090 --> 00:13:39,459

that means it's different amount of

341

00:13:44,009 --> 00:13:42,100

ammonia gases in the atmosphere so we're

342

00:13:46,680 --> 00:13:44,019

seeing ammonia gas bubbles here coming

343

00:13:48,120 --> 00:13:46,690

on up in the atmosphere and they have

344

00:13:49,949 --> 00:13:48,130

the same size with same shape as the

345

00:13:51,180 --> 00:13:49,959

clouds I just showed you the plumes so

346

00:13:53,130 --> 00:13:51,190

we think we've got this unique thing

347

00:13:54,600 --> 00:13:53,140

we've got the bubbles and plumes coming

348

00:13:57,240 --> 00:13:54,610

up showing dramatic up weld nvidia tegra

349

00:13:59,069 --> 00:13:57,250

tore a region of saturn and that then

350

00:14:00,630 --> 00:13:59,079

probably gives you these clouds that

351

00:14:01,920 --> 00:14:00,640

we've always been wondering why is there

352

00:14:03,689 --> 00:14:01,930

more clouds and equator well it's

353

00:14:07,019 --> 00:14:03,699

probably due to that now here's a quick

354

00:14:08,819 --> 00:14:07,029

tour of Saturn Indiana Jones meets

355

00:14:11,250 --> 00:14:08,829

Saturn a second you got to understand

356

00:14:13,050 --> 00:14:11,260

why you say this this is a not your

357

00:14:15,720 --> 00:14:13,060

normal Saturn this is a much more

358

00:14:17,880 --> 00:14:15,730

ominous much more ominous looking Saturn

359

00:14:21,389 --> 00:14:17,890

than you expect in those you can just

360

00:14:23,380 --> 00:14:21,399

thing to work there is no I'll talk

361

00:14:26,230 --> 00:14:23,390

about

362

00:14:28,090 --> 00:14:26,240

so Saturn is no longer boring in my 20

363

00:14:30,160 --> 00:14:28,100

okay here's the hexagon going through

364

00:14:31,720 --> 00:14:30,170

like an axle of a wheel and then beyond

365

00:14:33,730 --> 00:14:31,730

you got the string of pearls going on

366

00:14:34,420 --> 00:14:33,740

here this is a feature puppy very much

367

00:14:36,550 --> 00:14:34,430

of Abitibi

368

00:14:38,590 --> 00:14:36,560

24 lights that are in the atmosphere

369

00:14:40,000 --> 00:14:38,600

that have been down there now for four

370

00:14:41,170 --> 00:14:40,010

years we just saw him again

371

00:14:42,880 --> 00:14:41,180

first time we've had a chance look it

372

00:14:44,860 --> 00:14:42,890

said it was a week ago and just driving

373

00:14:46,150 --> 00:14:44,870

over here my postdoc called me said

374

00:14:47,680 --> 00:14:46,160

guess what we still got the pearl so now

375

00:14:49,569 --> 00:14:47,690

we've got our four years of pearls data

376

00:14:51,940 --> 00:14:49,579

there and we don't know what they are

377

00:14:53,889 --> 00:14:51,950

these are so I think in a second if I

378

00:14:55,120 --> 00:14:53,899

got time but it's very bizarre features

379

00:14:56,920 --> 00:14:55,130

we have that we also have done it's

380

00:14:59,019 --> 00:14:56,930

here's a donut going by I say you know

381

00:15:00,430 --> 00:14:59,029

don't be in the atmosphere there were a

382

00:15:02,620 --> 00:15:00,440

lot of D things so I'm gonna keep going

383

00:15:04,300 --> 00:15:02,630

here here's the pearls okay so you lots

384

00:15:06,100 --> 00:15:04,310

of pearls here but only covers about a

385

00:15:07,900 --> 00:15:06,110

quarter the planet so it can't quite be

386

00:15:09,699 --> 00:15:07,910

a total planetary way because doesn't go

387

00:15:12,340 --> 00:15:09,709

around so but they've been there for

388

00:15:14,680 --> 00:15:12,350

four for four years we have no idea so

389

00:15:15,940 --> 00:15:14,690

this number here now 4.2 not 2.8 and

390

00:15:17,230 --> 00:15:15,950

this to show you that they've been there

391

00:15:19,329 --> 00:15:17,240

all the way to the mission every time

392

00:15:20,889 --> 00:15:19,339

we've looked here's a donut let's wait

393

00:15:22,329 --> 00:15:20,899

before all done because this is actually

394

00:15:24,220 --> 00:15:22,339

again you're looking at thermal light so

395

00:15:25,810 --> 00:15:24,230

that's a clearing and then this circular

396

00:15:28,269 --> 00:15:25,820

black thing is a cloud so it's really

397

00:15:31,150 --> 00:15:28,279

like a donut or torus to write a cloud

398

00:15:31,630 --> 00:15:31,160

they are up around 53 degrees north

399

00:15:33,699 --> 00:15:31,640

latitude

400

00:15:35,710 --> 00:15:33,709

here's Dax agon that we got it first

401

00:15:37,210 --> 00:15:35,720

clear view I'll for you about a Voyager

402

00:15:39,790 --> 00:15:37,220

but this little mission because we go up

403

00:15:41,439 --> 00:15:39,800

over the pole we can look down so we get

404

00:15:43,300 --> 00:15:41,449

a very clear view of it and here it is

405

00:15:45,400 --> 00:15:43,310

here's a Sun rising oh here's some Sun

406

00:15:47,889 --> 00:15:45,410

rising this has been in darkness until

407

00:15:49,720 --> 00:15:47,899

recently the equinox just happened so

408

00:15:52,480 --> 00:15:49,730

now it is getting left but up until this

409

00:15:54,250 --> 00:15:52,490

recently it was in total darkness a lot

410

00:15:55,600 --> 00:15:54,260

sex relations for this thing coming out

411

00:15:58,300 --> 00:15:55,610

of the woodwork this is the best

412

00:15:59,560 --> 00:15:58,310

explanation we never the park looking

413

00:16:00,910 --> 00:15:59,570

trying to come up the real explanation

414

00:16:03,850 --> 00:16:00,920

this was in the paper I headed up a

415

00:16:06,430 --> 00:16:03,860

dispute astok anyway so

416

00:16:08,800 --> 00:16:06,440

so now we've got this view here so

417

00:16:10,660 --> 00:16:08,810

here's the actual poll and you to see

418

00:16:12,400 --> 00:16:10,670

this now we're looking at the winds

419

00:16:14,260 --> 00:16:12,410

around X argon but look at in here in

420

00:16:15,850 --> 00:16:14,270

the cyclone as a cyclone feature you see

421

00:16:17,770 --> 00:16:15,860

winds blowing very fast these little

422

00:16:19,030 --> 00:16:17,780

cloud features going very fast here but

423

00:16:21,010 --> 00:16:19,040

look out here these cloud features that

424

00:16:22,690 --> 00:16:21,020

move it off so you have this sort of

425

00:16:23,710 --> 00:16:22,700

well pull affective there's a cyclone at

426

00:16:25,540 --> 00:16:23,720

the pole that we didn't know about

427

00:16:26,740 --> 00:16:25,550

we've now documented it and there's you

428

00:16:29,020 --> 00:16:26,750

can see it visually right there a little

429

00:16:31,540 --> 00:16:29,030

whirlpool at the North Pole

430

00:16:33,490 --> 00:16:31,550

let's go skip over this that was a

431

00:16:34,240 --> 00:16:33,500

hurricane on the earth compared to

432

00:16:36,850 --> 00:16:34,250

compare to that

433

00:16:39,160 --> 00:16:36,860

okay now the South Pole also has a

434

00:16:40,210 --> 00:16:39,170

cyclone and it's much more hurricane

435

00:16:41,710 --> 00:16:40,220

like in the sense that you have

436

00:16:42,850 --> 00:16:41,720

different depths in this this is showing

437

00:16:44,530 --> 00:16:42,860

three different colors for different

438

00:16:46,510 --> 00:16:44,540

levels in the atmosphere red means at

439

00:16:47,920 --> 00:16:46,520

state green is a sill that higher up and

440

00:16:49,480 --> 00:16:47,930

Louie that's high then you can see in

441

00:16:51,250 --> 00:16:49,490

the eye of this it's a deep atmosphere

442

00:16:52,360 --> 00:16:51,260

much like a hurricane feature on the

443

00:16:53,710 --> 00:16:52,370

earth although the scale here is

444

00:16:55,660 --> 00:16:53,720

tremendously different indirect aids on

445

00:16:57,760 --> 00:16:55,670

earth but it seems to have a hurricane

446

00:16:59,440 --> 00:16:57,770

like feature in a fact if you look from

447

00:17:00,970 --> 00:16:59,450

the side you get close like the ISS

448

00:17:02,770 --> 00:17:00,980

people this is the camera people can do

449

00:17:04,329 --> 00:17:02,780

that you see shadows so here you can see

450

00:17:07,000 --> 00:17:04,339

this clouds these clouds are much higher

451
00:17:08,680 --> 00:17:07,010
than the clouds here casting shadows on

452
00:17:10,510 --> 00:17:08,690
the lower cloud that you get a 3d effect

453
00:17:12,189 --> 00:17:10,520
it's really real you're actually seeing

454
00:17:14,199 --> 00:17:12,199
the clouds in three dimension they're so

455
00:17:15,610 --> 00:17:14,209
high up to about 70 kilometers above the

456
00:17:17,199 --> 00:17:15,620
rest of the atmosphere there so we have

457
00:17:19,180 --> 00:17:17,209
this unique cyclone to South Pole looks

458
00:17:20,560 --> 00:17:19,190
a lot like hurricane then we have the

459
00:17:22,570 --> 00:17:20,570
thunderstorms and here's something the

460
00:17:24,820 --> 00:17:22,580
storms that we're seeing at the in the

461
00:17:26,350 --> 00:17:24,830
stem storm alley area about 35 degrees

462
00:17:27,220 --> 00:17:26,360
south it turns out the southern

463
00:17:28,300 --> 00:17:27,230

hemisphere doesn't have all these

464

00:17:29,950 --> 00:17:28,310

features I've been talking about another

465

00:17:32,320 --> 00:17:29,960

name is your donuts and curls but it

466

00:17:34,930 --> 00:17:32,330

does have spendest or mountain and we've

467

00:17:36,700 --> 00:17:34,940

been seeing discharges and the radio

468

00:17:39,310 --> 00:17:36,710

signals like using your AM radio and

469

00:17:41,350 --> 00:17:39,320

we've been seeing discharges off to the

470

00:17:43,360 --> 00:17:41,360

mission almost most of time for the

471

00:17:44,710 --> 00:17:43,370

mission of lightning but you can't see

472

00:17:46,990 --> 00:17:44,720

the light and visually nobody's single

473

00:17:48,880 --> 00:17:47,000

visually however you see strange things

474

00:17:49,480 --> 00:17:48,890

when you go to images and here's a

475

00:17:51,370 --> 00:17:49,490

strange thing

476

00:17:53,560 --> 00:17:51,380

dark clouds hey dark clouds here and a

477

00:17:55,630 --> 00:17:53,570

bright cloud here this bright cloud is

478

00:17:57,370 --> 00:17:55,640

made up of ammonia now we could confirm

479

00:17:58,900 --> 00:17:57,380

that and that our cloud here is dark

480

00:18:01,180 --> 00:17:58,910

throughout the whole spectrum so what is

481

00:18:02,560 --> 00:18:01,190

dark the whole spectrum you might think

482

00:18:04,120 --> 00:18:02,570

of charcoal and that's indeed what we

483

00:18:07,060 --> 00:18:04,130

think it is paper just got published on

484

00:18:09,760 --> 00:18:07,070

this so we think we've got dark charcoal

485

00:18:11,350 --> 00:18:09,770

like stuff upwelling this argument if

486

00:18:13,570 --> 00:18:11,360

you think it's a layer of soot here

487

00:18:15,760 --> 00:18:13,580

which is coming out up and the ammonia

488

00:18:17,570 --> 00:18:15,770

cloud comes out first as you updraft

489

00:18:19,160 --> 00:18:17,580

these things wind up here kind of blows

490

00:18:20,600 --> 00:18:19,170

you want to cut around but does it but

491

00:18:22,790 --> 00:18:20,610

beyond the ammonia club beneath the

492

00:18:24,290 --> 00:18:22,800

dwell is a few days later this sort of

493

00:18:26,560 --> 00:18:24,300

dark material which is embedded in the

494

00:18:29,150 --> 00:18:26,570

ice and we think now there's probably a

495

00:18:30,650 --> 00:18:29,160

charcoal like substance sitting down

496

00:18:32,600 --> 00:18:30,660

there all the time in the depths of

497

00:18:34,280 --> 00:18:32,610

Saturn on the 10 bar level very far down

498

00:18:36,110 --> 00:18:34,290

honey on this scale here about 200

499

00:18:38,000 --> 00:18:36,120

kilometers down from the one of our

500

00:18:39,800 --> 00:18:38,010

level and periodically we get these huge

501
00:18:43,070 --> 00:18:39,810
up your ass with thunderstorms powered

502
00:18:44,780 --> 00:18:43,080
by pipe by water some of your that

503
00:18:46,160 --> 00:18:44,790
release of energy brings a stuff up but

504
00:18:48,440 --> 00:18:46,170
we think we get to the black spots so

505
00:18:55,100 --> 00:18:48,450
that's a very recent funny okay

506
00:18:56,510 --> 00:18:55,110
blasting as Aurora okay so we have that

507
00:18:58,640 --> 00:18:56,520
we have these are all right which can be

508
00:19:00,430 --> 00:18:58,650
done by several different instruments we

509
00:19:02,660 --> 00:19:00,440
have Northern Lights basically on

510
00:19:05,480 --> 00:19:02,670
Saturday and here it is with the UV

511
00:19:07,460 --> 00:19:05,490
ultraviolet light side seat of CH and

512
00:19:10,100 --> 00:19:07,470
then we CH 3 plus which is like which is

513
00:19:11,540 --> 00:19:10,110

a chemical that's above in the actually

514

00:19:13,730 --> 00:19:11,550

formation of aerosols two out of this

515

00:19:15,800 --> 00:19:13,740

comes aerosols just like on Jupiter and

516

00:19:17,540 --> 00:19:15,810

we're starting now document this takes a

517

00:19:19,070 --> 00:19:17,550

little bit of effort for our camera to

518

00:19:20,870 --> 00:19:19,080

actually get these types of these types

519

00:19:23,660 --> 00:19:20,880

of observations but do you have an order

520

00:19:24,950 --> 00:19:23,670

right over the hexagon we I don't think

521

00:19:27,170 --> 00:19:24,960

is a coincidence but a lot of people are

522

00:19:28,010 --> 00:19:27,180

thinking I think it's coincidence but a

523

00:19:29,630 --> 00:19:28,020

lot of people thinking maybe of some

524

00:19:31,370 --> 00:19:29,640

cause-and-effect we don't think so this

525

00:19:34,250 --> 00:19:31,380

thing's way up high at my crowbar level

526

00:19:35,900 --> 00:19:34,260

whereas the hexagon is down one to two

527

00:19:36,770 --> 00:19:35,910

or three bars it's done it so I don't

528

00:19:38,390 --> 00:19:36,780

think has any real effect just

529

00:19:39,650 --> 00:19:38,400

coincidence here that you get your

530

00:19:41,510 --> 00:19:39,660

hanging around this but it's very

531

00:19:43,850 --> 00:19:41,520

beautiful picture here of the site of

532

00:19:46,220 --> 00:19:43,860

the the cyclone at the pole in the or

533

00:19:48,320 --> 00:19:46,230

and the hexagon in the aura above it

534

00:19:49,850 --> 00:19:48,330

lingering there so I'm just thinking

535

00:19:51,470 --> 00:19:49,860

this famous picture I think anybody's

536

00:19:54,740 --> 00:19:51,480

seen as I get Steven iceberg in turn

537

00:19:56,180 --> 00:19:54,750

might even of unique view of Saturn

538

00:19:57,800 --> 00:19:56,190

this is SATA right here with the Sun

539

00:19:59,180 --> 00:19:57,810

behind it so it's in eclipse and then

540

00:20:01,970 --> 00:19:59,190

you see the ring shimmering in the

541

00:20:04,700 --> 00:20:01,980

sunlight and if you haven't seen it here

542

00:20:06,110 --> 00:20:04,710

over here is actually us right there and

543

00:20:08,540 --> 00:20:06,120

if you blow it up you can weight

544

00:20:10,400 --> 00:20:08,550

yourself there we are billion miles away

545

00:20:12,470 --> 00:20:10,410

this is a picture taken - unbelievable

546

00:20:14,180 --> 00:20:12,480

seeing the earth basically shimmering

547

00:20:15,950 --> 00:20:14,190

through the rings of Saturn in eclipse

548

00:20:17,720 --> 00:20:15,960

so let's not me the most of the iconic

549

00:20:19,490 --> 00:20:17,730

this is the iconic picture I think of

550

00:20:30,040 --> 00:20:19,500

the mission so far so go ahead at the

551

00:20:35,180 --> 00:20:33,590

there will be opportunity to ask

552

00:20:36,860 --> 00:20:35,190

questions the reason I'm asking all the

553

00:20:39,470 --> 00:20:36,870

speakers to zoom through is so that we

554

00:20:45,080 --> 00:20:39,480

can have a really nice long Q&A section

555

00:20:46,730 --> 00:20:45,090

after this so thank you and I talked

556

00:20:49,070 --> 00:20:46,740

about this talk Saturn's magnificent

557

00:20:52,010 --> 00:20:49,080

rings because I really think that Saturn

558

00:20:54,440 --> 00:20:52,020

has a great ring system Kevin showed you

559

00:20:56,720 --> 00:20:54,450

the outer gas giant planets all of them

560

00:20:58,310 --> 00:20:56,730

have ring systems but without a doubt

561

00:21:00,799 --> 00:20:58,320

the Saturn ring system is the most

562

00:21:03,290 --> 00:21:00,809

extensive and I think in many ways the

563

00:21:05,060 --> 00:21:03,300

most beautiful the Rings have very

564

00:21:07,460 --> 00:21:05,070

simple names they're just the letters of

565

00:21:08,930 --> 00:21:07,470

the alphabet and that we've gotten a

566

00:21:10,820 --> 00:21:08,940

little bit more creative with Cassini as

567

00:21:12,799 --> 00:21:10,830

we've discovered new rings we tend to if

568

00:21:14,840 --> 00:21:12,809

they're affiliated with moons and named

569

00:21:16,490 --> 00:21:14,850

them after the motors but here if you

570

00:21:19,360 --> 00:21:16,500

look through a telescope the main rings

571

00:21:21,830 --> 00:21:19,370

that you would see would be ABCD and

572

00:21:24,260 --> 00:21:21,840

perhaps even with a good telescope a

573

00:21:25,760 --> 00:21:24,270

chance to see the Cassini division there

574

00:21:27,530 --> 00:21:25,770

are other rings that Saturn as well

575

00:21:29,299 --> 00:21:27,540

there's a very narrow effort you can

576

00:21:31,580 --> 00:21:29,309

just see it in this image here just

577

00:21:34,820 --> 00:21:31,590

outside the edge of the a ring we've got

578

00:21:36,710 --> 00:21:34,830

the G ring very extensive earring we've

579

00:21:38,810 --> 00:21:36,720

also over the course of the Cassini

580

00:21:41,480 --> 00:21:38,820

mission discovered a host of tiny new

581

00:21:44,060 --> 00:21:41,490

moons like Pauline that has a ring

582

00:21:45,140 --> 00:21:44,070

associated with it or anthe and one

583

00:21:46,820 --> 00:21:45,150

thing I heard that's kind of interesting

584

00:21:49,490 --> 00:21:46,830

when we were discovering these tiny

585

00:21:51,560 --> 00:21:49,500

moons they often seem to have rings and

586

00:21:53,750 --> 00:21:51,570

one analogy might be when you when you

587

00:21:56,750 --> 00:21:53,760

see a dog a dog often has fleas so if

588

00:22:01,900 --> 00:21:56,760

you think of the tiny moons like little

589

00:22:07,310 --> 00:22:04,970

for scale that the saturn plus its rings

590

00:22:09,290 --> 00:22:07,320

is is really a huge system

591

00:22:11,540 --> 00:22:09,300

this shows Saturn the earth and the moon

592

00:22:13,850 --> 00:22:11,550

to scale in the distance between them is

593

00:22:16,310 --> 00:22:13,860

to scale as well and you can see that

594

00:22:19,070 --> 00:22:16,320

you can just neatly fit Saturn plus the

595

00:22:21,380 --> 00:22:19,080

Rings in between the earth and the moon

596

00:22:23,600 --> 00:22:21,390

and the Rings are made primarily of

597

00:22:26,570 --> 00:22:23,610

water ice and we as we've learned with

598

00:22:29,060 --> 00:22:26,580

Cassini those water ice particles tend

599

00:22:31,850 --> 00:22:29,070

to clump into pulpy structures

600

00:22:33,920 --> 00:22:31,860

especially in the a and the B rings they

601
00:22:37,040 --> 00:22:33,930
range in size and the main rings from

602
00:22:39,500 --> 00:22:37,050
Marble sizes up to large houses and even

603
00:22:41,030 --> 00:22:39,510
mountain sized particles and so one of

604
00:22:42,620 --> 00:22:41,040
the neat news discoveries with Cassini

605
00:22:45,380 --> 00:22:42,630
as effect of these particles tend to

606
00:22:47,840 --> 00:22:45,390
clump up if you go back and before

607
00:22:50,630 --> 00:22:47,850
Voyager before Cassini there was another

608
00:22:56,230 --> 00:22:50,640
very interesting idea about what's an

609
00:23:00,020 --> 00:22:56,240
injury ever wonder where you're sitting

610
00:23:04,130 --> 00:23:00,030
Milton lax now you know might be part of

611
00:23:05,990 --> 00:23:04,140
Saturn trees this is a movie of the

612
00:23:08,180 --> 00:23:06,000
Rings it's starting on the lit side you

613
00:23:10,580 --> 00:23:08,190

can see the a ring Cassini division and

614

00:23:15,050 --> 00:23:10,590

V ring let's see if we can get it to

615

00:23:16,940 --> 00:23:15,060

play here there it goes and this is some

616

00:23:20,090 --> 00:23:16,950

pictures taken by the Cassini spacecraft

617

00:23:22,430 --> 00:23:20,100

as we're flying we were fun as we're

618

00:23:24,770 --> 00:23:22,440

trying to fly through the rings edge on

619

00:23:29,450 --> 00:23:24,780

and you'll go through see the man John I

620

00:23:29,460 --> 00:23:36,080

give up one more shot

621

00:23:40,490 --> 00:23:38,360

okay well as you go through what you'll

622

00:23:42,080 --> 00:23:40,500

see is this optically what you would

623

00:23:44,270 --> 00:23:42,090

have seen is this optically thick B ring

624

00:23:45,830 --> 00:23:44,280

becomes very dark there's a little bit

625

00:23:48,140 --> 00:23:45,840

of material here in the Cassini division

626

00:23:49,760 --> 00:23:48,150

and that brightens up it's really kind

627

00:23:52,640 --> 00:23:49,770

of fun just to write along with the

628

00:23:56,150 --> 00:23:52,650

Cassini spacecraft and watch as well as

629

00:23:57,860 --> 00:23:56,160

we go by the Rings now the big event was

630

00:23:59,840 --> 00:23:57,870

the equinox and so I'm going to spend

631

00:24:01,010 --> 00:23:59,850

some time you saw some of these images

632

00:24:04,250 --> 00:24:01,020

that you are here for the virtual

633

00:24:06,290 --> 00:24:04,260

singers this is a mosaic of 75 frames

634

00:24:09,020 --> 00:24:06,300

put together through a series of filters

635

00:24:10,970 --> 00:24:09,030

so we can have a colored image and this

636

00:24:13,070 --> 00:24:10,980

is what Saturn in the ring system looks

637

00:24:15,710 --> 00:24:13,080

like with the Sun just edged on to the

638

00:24:18,740 --> 00:24:15,720

race now this event occurs only once

639

00:24:20,570 --> 00:24:18,750

every 15 years and we were very lucky to

640

00:24:22,370 --> 00:24:20,580

have the Cassini spacecraft there we

641

00:24:24,500 --> 00:24:22,380

were in an orbit of inclined about 20

642

00:24:26,240 --> 00:24:24,510

degrees be able to look at the Rings

643

00:24:28,400 --> 00:24:26,250

because when the Rings are edged on with

644

00:24:29,990 --> 00:24:28,410

respect to the Sun they're essentially

645

00:24:32,750 --> 00:24:30,000

edged on with respect to the earth as

646

00:24:34,160 --> 00:24:32,760

well and so it's very difficult to

647

00:24:36,860 --> 00:24:34,170

observe the Rings we got a whole

648

00:24:40,280 --> 00:24:36,870

brand-new data set in just this August

649

00:24:42,380 --> 00:24:40,290

August 11th was Equinox in this series

650

00:24:44,960 --> 00:24:42,390

of frames we've had to brighten up the

651
00:24:46,790 --> 00:24:44,970
Rings by about a factor of 20 if we

652
00:24:48,950 --> 00:24:46,800
didn't do that you they'd basically be

653
00:24:50,900 --> 00:24:48,960
invisible when compared to the light

654
00:24:53,990 --> 00:24:50,910
from the planet we've also had to

655
00:24:56,180 --> 00:24:54,000
brighten up the dark darker region of

656
00:24:58,340 --> 00:24:56,190
the Rings as well what you're seeing now

657
00:25:00,770 --> 00:24:58,350
is the Rings essentially illuminated by

658
00:25:03,560 --> 00:25:00,780
Saturn shine it's as though you've

659
00:25:05,000 --> 00:25:03,570
essentially turned off the sunlight and

660
00:25:07,490 --> 00:25:05,010
you get to see what the rings look like

661
00:25:09,680 --> 00:25:07,500
just in the light coming from the planet

662
00:25:12,770 --> 00:25:09,690
and as you can see going back here

663
00:25:15,320 --> 00:25:12,780

what's brightest edge-on is the F rate

664

00:25:16,790 --> 00:25:15,330

that the F remains bright throughout the

665

00:25:20,420 --> 00:25:16,800

equitable silence at the edge

666

00:25:21,860 --> 00:25:20,430

the Rings just want to show you some

667

00:25:23,450 --> 00:25:21,870

highlights when you can look at the

668

00:25:25,310 --> 00:25:23,460

Rings edge all and what it does is it

669

00:25:27,530 --> 00:25:25,320

gives you a chance to look at the

670

00:25:30,170 --> 00:25:27,540

three-dimensional structure in the race

671

00:25:32,420 --> 00:25:30,180

and anything that sticks up above or

672

00:25:34,550 --> 00:25:32,430

below that that plane of the Rings which

673

00:25:36,710 --> 00:25:34,560

is only about we're thinking on the

674

00:25:38,240 --> 00:25:36,720

order of maybe 10 or it's 230 feet thick

675

00:25:40,700 --> 00:25:38,250

it's not very thick compared to its

676
00:25:42,190 --> 00:25:40,710
extent anything that sticks up above and

677
00:25:44,900 --> 00:25:42,200
below is going to be bright in

678
00:25:47,600 --> 00:25:44,910
particular there's a gap here Yankee gap

679
00:25:49,730 --> 00:25:47,610
a tiny moonlit pan orbits inside of it

680
00:25:52,220 --> 00:25:49,740
and you can see these bright ringlets

681
00:25:54,740 --> 00:25:52,230
have clumped up or actually sticking up

682
00:25:57,140 --> 00:25:54,750
above or in the case of the darker

683
00:25:59,090 --> 00:25:57,150
regions perhaps below the Rings we can

684
00:26:00,280 --> 00:25:59,100
see the clumpiness by looking the Sun

685
00:26:03,080 --> 00:26:00,290
lights coming from this direction

686
00:26:06,230 --> 00:26:03,090
another tiny gap the Anki gap has a

687
00:26:07,880 --> 00:26:06,240
gardening Daphna staff neces orbit is

688
00:26:10,640 --> 00:26:07,890

slightly tilted with respect to the

689

00:26:13,070 --> 00:26:10,650

Rings and it pulls the ring material out

690

00:26:14,960 --> 00:26:13,080

of the plane you also see other places

691

00:26:16,910 --> 00:26:14,970

here's a bending wave a place where

692

00:26:18,710 --> 00:26:16,920

material is lifted above and below the

693

00:26:20,750 --> 00:26:18,720

ring plate and not only is it bright but

694

00:26:21,950 --> 00:26:20,760

it casts a shadow so you can see a

695

00:26:24,710 --> 00:26:21,960

shadow and there are other bright

696

00:26:26,740 --> 00:26:24,720

features in this view as well just want

697

00:26:28,790 --> 00:26:26,750

to zoom in on this area with deafness

698

00:26:30,620 --> 00:26:28,800

what you can see here this is an

699

00:26:32,570 --> 00:26:30,630

enhanced image but you can see the

700

00:26:35,240 --> 00:26:32,580

shadow in this structure that's coming

701
00:26:37,010 --> 00:26:35,250
up perhaps as much as eight miles above

702
00:26:40,430 --> 00:26:37,020
the ring plane in this very narrow

703
00:26:44,000 --> 00:26:42,350
this one a briefly go over some of the

704
00:26:45,800 --> 00:26:44,010
key objectives we're looking forward to

705
00:26:49,310 --> 00:26:45,810
the next seven years we'd like to go

706
00:26:51,230 --> 00:26:49,320
from equinox to seven years from now go

707
00:26:53,240 --> 00:26:51,240
to the Solstice out to the Saturn

708
00:26:55,100 --> 00:26:53,250
solstice some of the things we want to

709
00:26:57,590 --> 00:26:55,110
look for our seasonal and temporal

710
00:27:00,170 --> 00:26:57,600
changes how do the Rings change with the

711
00:27:02,390 --> 00:27:00,180
seasons and as time passes there are

712
00:27:04,490 --> 00:27:02,400
these very interesting finger like dusty

713
00:27:06,830 --> 00:27:04,500

spokes they're particles elevated above

714

00:27:09,110 --> 00:27:06,840

the Rings how do they evolve and what's

715

00:27:11,150 --> 00:27:09,120

happening with those understand more

716

00:27:13,760 --> 00:27:11,160

about this micro scale properties and

717

00:27:15,200 --> 00:27:13,770

clumping in the Rings also to understand

718

00:27:16,940 --> 00:27:15,210

about the time variability of these

719

00:27:20,720 --> 00:27:16,950

structures how do they change with time

720

00:27:22,190 --> 00:27:20,730

as you look from years to decades some

721

00:27:24,500 --> 00:27:22,200

new questions we'd like to constrain the

722

00:27:26,150 --> 00:27:24,510

age of the Rings parts of the Rings that

723

00:27:28,130 --> 00:27:26,160

look very young maybe only a hundred

724

00:27:29,600 --> 00:27:28,140

million years old if there are other

725

00:27:32,630 --> 00:27:29,610

parts perhaps there's a renewal process

726

00:27:34,670 --> 00:27:32,640

going on that perhaps the very thickest

727

00:27:36,890 --> 00:27:34,680

earring might be as old as the Saturn

728

00:27:38,750 --> 00:27:36,900

system itself we'd like to get more

729

00:27:41,360 --> 00:27:38,760

information and hopefully be able to

730

00:27:43,070 --> 00:27:41,370

answer that question also understand a

731

00:27:45,410 --> 00:27:43,080

little better how so the neon gaps are

732

00:27:47,540 --> 00:27:45,420

cleared some of these like the gap here

733

00:27:49,070 --> 00:27:47,550

has a tiny moon inside it but other gaps

734

00:27:51,440 --> 00:27:49,080

we've looked and looked and have yet to

735

00:27:53,990 --> 00:27:51,450

find any evidence for moons that are

736

00:27:56,300 --> 00:27:54,000

keeping these gaps open so how are these

737

00:27:58,550 --> 00:27:56,310

gaps kept open we'd like to find out and

738

00:28:00,080 --> 00:27:58,560

then to determine the composition of the

739

00:28:02,690 --> 00:28:00,090

Rings they're mostly water eyes with

740

00:28:03,890 --> 00:28:02,700

their little bits of contaminants in the

741

00:28:05,360 --> 00:28:03,900

Rings and it looks a little bit

742

00:28:07,490 --> 00:28:05,370

different depending on where you look

743

00:28:09,440 --> 00:28:07,500

and which ring look through and so we'd

744

00:28:13,190 --> 00:28:09,450

like a chance to study that even further

745

00:28:15,350 --> 00:28:13,200

and finally this is one of my favorite

746

00:28:17,420 --> 00:28:15,360

pictures it's a unique geometry and you

747

00:28:20,060 --> 00:28:17,430

can only get with a spacecraft like

748

00:28:22,250 --> 00:28:20,070

Cassini or looking at here is that we're

749

00:28:24,290 --> 00:28:22,260

using Saturn to basically block out the

750

00:28:25,760 --> 00:28:24,300

sunlight you can see a little bit of the

751

00:28:27,919 --> 00:28:25,770

sunlight peeking through

752

00:28:29,830 --> 00:28:27,929

around the limb of the planet and it

753

00:28:32,120 --> 00:28:29,840

does a nice job in particular

754

00:28:34,010 --> 00:28:32,130

highlighting the dusty rings imagine

755

00:28:36,169 --> 00:28:34,020

yourself driving on the freeway on an

756

00:28:37,730 --> 00:28:36,179

afternoon with a dusty windshield you

757

00:28:40,430 --> 00:28:37,740

drive into the Sun and suddenly it's

758

00:28:42,380 --> 00:28:40,440

very hard to see is the same effect with

759

00:28:44,720 --> 00:28:42,390

the Rings as the sunlight shines through

760

00:28:46,850 --> 00:28:44,730

the Rings they brighten up just as your

761

00:28:49,250 --> 00:28:46,860

windshield would brighten up if it's if

762

00:28:51,260 --> 00:28:49,260

it's very dusty and this is a unique

763

00:28:53,540 --> 00:28:51,270

picture also as Kevin pointed out in

764

00:28:56,990 --> 00:28:53,550

that tiny square in that square there is

765

00:28:59,570 --> 00:28:57,000

a pale blue dot and that dot is the

766

00:29:02,720 --> 00:28:59,580

earth-moon system and so here's one case

767

00:29:06,830 --> 00:29:02,730

where Cassini is looking back and taking

768

00:29:08,960 --> 00:29:06,840

a picture of half the people on earth so

769

00:29:11,060 --> 00:29:08,970

stay tuned hopefully on Cassini are

770

00:29:13,400 --> 00:29:11,070

there plans to go for another 7 years

771

00:29:15,080 --> 00:29:13,410

and continue to return great pictures

772

00:29:17,540 --> 00:29:15,090

not only of the Rings at the rest of the

773

00:29:19,280 --> 00:29:17,550

Saturn system with that I'd like to turn

774

00:29:33,350 --> 00:29:19,290

over to Tomas to tell you about that

775

00:29:36,320 --> 00:29:33,360

invisible magnetosphere rings Saturn's

776

00:29:38,630 --> 00:29:36,330

magnetosphere is about a few million

777

00:29:42,440 --> 00:29:38,640

times bigger than the planet and Eric's

778

00:29:48,380 --> 00:29:42,450

combined together as a matter of fact it

779

00:29:51,530 --> 00:29:48,390

also implies and and and means that the

780

00:29:53,690 --> 00:29:51,540

universe 99% of the universities across

781

00:29:54,860 --> 00:29:53,700

mistake plasma state means that it's

782

00:30:00,130 --> 00:29:54,870

ionized McKay

783

00:30:02,390 --> 00:30:00,140

so I will be trying to talk about the

784

00:30:06,920 --> 00:30:02,400

magnetosphere which is the plasma

785

00:30:08,870 --> 00:30:06,930

environment of Saturn I would like to

786

00:30:12,890 --> 00:30:08,880

introduce the concept of a magnetosphere

787

00:30:16,220 --> 00:30:12,900

so if you have a magnetic dipole you put

788

00:30:19,160 --> 00:30:16,230

it into a very fast flowing flow in this

789

00:30:21,460 --> 00:30:19,170

case the solar beam which is the plasma

790

00:30:24,140 --> 00:30:21,470

stream very high-speed plasma stream

791

00:30:27,640 --> 00:30:24,150

emanating from the Sun which is

792

00:30:30,470 --> 00:30:27,650

supersonic so much that the Mach number

793

00:30:33,920 --> 00:30:30,480

the speed of the solar wind is about

794

00:30:36,370 --> 00:30:33,930

1020 times higher than the Sun speed in

795

00:30:39,380 --> 00:30:36,380

there in the middle so this is a

796

00:30:43,040 --> 00:30:39,390

supersonic hypersonic bullet which is a

797

00:30:47,330 --> 00:30:43,050

magnet in a in a conducting fluid so

798

00:30:49,870 --> 00:30:47,340

what happens is that the magnet has its

799

00:30:53,570 --> 00:30:49,880

magnetic field lines but the streaming

800

00:30:58,160 --> 00:30:53,580

solar wind compresses the dayside of the

801
00:31:00,350 --> 00:30:58,170
magnetic field and expanse stretches the

802
00:31:03,770 --> 00:31:00,360
night side and the magnetosphere is

803
00:31:05,390 --> 00:31:03,780
basically the region of space that is

804
00:31:07,670 --> 00:31:05,400
dominated by the pantry

805
00:31:09,620 --> 00:31:07,680
distorted planetary magnetic field and

806
00:31:14,540 --> 00:31:09,630
its interaction with the surrounding

807
00:31:21,970 --> 00:31:14,550
medium so at Saturn the distance from

808
00:31:30,490 --> 00:31:24,800
stand of distance which is around here

809
00:31:36,040 --> 00:31:30,500
is about 25 planetary radii which is

810
00:31:39,830 --> 00:31:36,050
huge and on the night side there goes

811
00:31:43,930 --> 00:31:39,840
hundreds and even thousands of 20 radii

812
00:31:52,090 --> 00:31:43,940
for the total volume of the conductor I

813
00:31:59,620 --> 00:31:57,070

thank you so the total volume occupied

814

00:32:01,720 --> 00:31:59,630

by the magnetosphere is millions of

815

00:32:06,340 --> 00:32:01,730

times larger than the volume of the

816

00:32:09,399 --> 00:32:06,350

planet sentence magnetosphere basically

817

00:32:11,830 --> 00:32:09,409

encompasses most of the planetary

818

00:32:15,090 --> 00:32:11,840

satellites and this is a very nice

819

00:32:19,630 --> 00:32:15,100

cartoon made by the Cassini mini team

820

00:32:23,340 --> 00:32:19,640

then is one of the particulate fields

821

00:32:26,260 --> 00:32:23,350

instruments on Cassini and you can see

822

00:32:29,190 --> 00:32:26,270

that the planet and its ring system is

823

00:32:32,320 --> 00:32:29,200

tiny here on the orbits of the various

824

00:32:34,930 --> 00:32:32,330

satellites it is Titan which orbits at

825

00:32:36,519 --> 00:32:34,940

twenty Center later on and then the

826

00:32:41,970 --> 00:32:36,529

magnetic field and the magnetosphere

827

00:32:45,760 --> 00:32:41,980

really extends much much further and

828

00:32:50,100 --> 00:32:45,770

what give us what we study is basically

829

00:32:53,970 --> 00:32:50,110

what is the dynamics and what is the

830

00:32:57,370 --> 00:32:53,980

configuration of this huge magnetosphere

831

00:33:00,370 --> 00:32:57,380

one of the major discoveries of Cassini

832

00:33:04,630 --> 00:33:00,380

was the discovery that Enceladus is

833

00:33:09,010 --> 00:33:04,640

basically the source of a lot of water

834

00:33:11,799 --> 00:33:09,020

vapor coming out is a montage of various

835

00:33:14,700 --> 00:33:11,809

images actually it shows that the curve

836

00:33:16,659 --> 00:33:14,710

in American cinema Leto meter the

837

00:33:20,139 --> 00:33:16,669

instrument that measures the magnetic

838

00:33:22,690 --> 00:33:20,149

field for the first Enceladus flyby

839

00:33:25,120 --> 00:33:22,700

detected a distortion of the magnetic

840

00:33:28,389 --> 00:33:25,130

field which is very firmly indicated

841

00:33:33,510 --> 00:33:28,399

that Enceladus is a source of huge

842

00:33:35,990 --> 00:33:33,520

amount of new plasma the or the next

843

00:33:38,720 --> 00:33:36,000

flyby

844

00:33:42,160 --> 00:33:38,730

the iron neutral mass spectrometer which

845

00:33:46,970 --> 00:33:42,170

measures individual molecules and ions

846

00:33:48,950 --> 00:33:46,980

detected a huge spike of water near and

847

00:33:52,880 --> 00:33:48,960

cylinders you can see that this is a

848

00:33:55,700 --> 00:33:52,890

good order of magnitude increase then

849

00:33:59,000 --> 00:33:55,710

the spacecraft passed the Sun near the

850

00:34:01,430 --> 00:33:59,010

southern pole and then the imaging

851
00:34:04,520 --> 00:34:01,440
instrument the camera looked then this

852
00:34:08,300 --> 00:34:04,530
very famous Cassini bloom was discovered

853
00:34:10,369 --> 00:34:08,310
and this image shows that the

854
00:34:12,619 --> 00:34:10,379
temperatures of the so-called tiger

855
00:34:17,330 --> 00:34:12,629
stripes which are the source of these

856
00:34:20,600 --> 00:34:17,340
guys even on Enceladus and this cartoon

857
00:34:23,360 --> 00:34:20,610
at the end shows that southern region of

858
00:34:25,970 --> 00:34:23,370
Enceladus is the source of a huge plume

859
00:34:28,460 --> 00:34:25,980
that becomes ionized and basically

860
00:34:32,330 --> 00:34:28,470
provides a very large amount of plasma

861
00:34:34,010 --> 00:34:32,340
for the magnetosphere of Center one of

862
00:34:36,200 --> 00:34:34,020
the biggest lessons we learned from

863
00:34:38,710 --> 00:34:36,210

Cassini and this is just another nice

864

00:34:42,020 --> 00:34:38,720

cartoon of Saturn's magnetosphere is

865

00:34:45,379 --> 00:34:42,030

that the center's magnetosphere is

866

00:34:50,510 --> 00:34:45,389

swimming in water and solidus is a major

867

00:34:54,440 --> 00:34:50,520

source of water it's about a thousand

868

00:34:58,580 --> 00:34:54,450

kilograms per second which is quite

869

00:35:01,610 --> 00:34:58,590

comparable to the material ejected from

870

00:35:04,610 --> 00:35:01,620

IO in Jupiter's magnetosphere the rings

871

00:35:08,120 --> 00:35:04,620

about an order of magnitude less 100

872

00:35:12,200 --> 00:35:08,130

kilos Saturn itself is even less so the

873

00:35:15,110 --> 00:35:12,210

major sources are drinks and Enceladus

874

00:35:17,420 --> 00:35:15,120

and this source this plasma source

875

00:35:20,810 --> 00:35:17,430

basically dominates the whole

876

00:35:24,380 --> 00:35:20,820

environment space environment of centre

877

00:35:27,890 --> 00:35:24,390

I also would like to talk a little bit

878

00:35:30,680 --> 00:35:27,900

about the Aurora and some of these

879

00:35:32,630 --> 00:35:30,690

images Carol showed the hexagon and our

880

00:35:38,800 --> 00:35:32,640

on top of each other

881

00:35:42,390 --> 00:35:38,810

Aurora is this blueish circle and

882

00:35:45,160 --> 00:35:42,400

at this hour is a highly spectacular

883

00:35:47,440 --> 00:35:45,170

phenomenon that is created by energetic

884

00:35:50,440 --> 00:35:47,450

particles precipitating from the

885

00:35:52,840 --> 00:35:50,450

magnetosphere and exciting about

886

00:35:55,510 --> 00:35:52,850

molecules and ions in the upper

887

00:35:58,120 --> 00:35:55,520

atmosphere of Earth the basic mechanism

888

00:36:02,740 --> 00:35:58,130

is the same etcetera so we learn a lot

889

00:36:05,890 --> 00:36:02,750

about the atmosphere and about the

890

00:36:12,340 --> 00:36:05,900

ionosphere by studying the Aurora in a

891

00:36:15,160 --> 00:36:12,350

very simple in a very simple analogy we

892

00:36:18,820 --> 00:36:15,170

could say that Aurora is like the

893

00:36:22,000 --> 00:36:18,830

old-fashioned TV screen that images the

894

00:36:24,850 --> 00:36:22,010

whole magnetosphere or or a large part

895

00:36:27,370 --> 00:36:24,860

of the magnetosphere to the screen of

896

00:36:29,620 --> 00:36:27,380

the upper atmosphere and there is a very

897

00:36:32,320 --> 00:36:29,630

strong connection between magnetospheric

898

00:36:37,960 --> 00:36:32,330

phenomena and magnetospheric dynamics

899

00:36:42,030 --> 00:36:37,970

and Aurora and one of the major research

900

00:36:46,090 --> 00:36:42,040

areas which is occupying the Cassini

901
00:36:48,760 --> 00:36:46,100
plasma science teams is the connection

902
00:36:51,030 --> 00:36:48,770
of magnetospheric dynamics to what we

903
00:36:58,270 --> 00:36:51,040
actually observe

904
00:37:00,640 --> 00:36:58,280
adora so they are still working and

905
00:37:04,330 --> 00:37:00,650
friends--the are one of the pioneers of

906
00:37:06,790 --> 00:37:04,340
of institute planetary science said that

907
00:37:09,310 --> 00:37:06,800
in planetary missions half the fun is

908
00:37:12,160 --> 00:37:09,320
just being in orbit and it is very very

909
00:37:13,900 --> 00:37:12,170
true because most of the fun is when you

910
00:37:17,650 --> 00:37:13,910
make new discoveries when you see

911
00:37:20,820 --> 00:37:17,660
something but is unexpected and the

912
00:37:25,600 --> 00:37:20,830
Cassini is full of unexpected results

913
00:37:29,890 --> 00:37:25,610

finally I'd like to show a brief video

914

00:37:32,140 --> 00:37:29,900

is because this basically puts the whole

915

00:37:32,900 --> 00:37:32,150

Cassini mission and the exploration of

916

00:37:36,470 --> 00:37:32,910

the planet

917

00:37:39,529 --> 00:37:36,480

into the solar system perspective this

918

00:37:46,569 --> 00:37:39,539

year earlier we had Michigan work

919

00:37:49,370 --> 00:37:46,579

together it's my talent for phenology

920

00:37:51,670 --> 00:37:49,380

you know when I was a student in in

921

00:37:54,710 --> 00:37:51,680

Hungary and I was in theoretical physics

922

00:37:58,930 --> 00:37:54,720

my professor strictly forbade me from

923

00:38:05,630 --> 00:38:03,230

touching any cause I was so successful

924

00:38:12,289 --> 00:38:05,640

that the traffic lights went out for a

925

00:38:13,809 --> 00:38:12,299

few hours so the earlier this year we

926
00:38:16,880 --> 00:38:13,819
worked with the Hayden Planetarium

927
00:38:22,039 --> 00:38:16,890
invented a new show the new show his

928
00:38:25,279 --> 00:38:22,049
journey to the Stars and it premiered

929
00:38:27,890 --> 00:38:25,289
sometimes early too and they use the

930
00:38:30,950 --> 00:38:27,900
three minutes of our simulations and

931
00:38:34,910 --> 00:38:30,960
visualize them showing the boy solar

932
00:38:37,080 --> 00:38:34,920
system from the Sun to versus enter the

933
00:38:41,640 --> 00:38:37,090
edge of the solar system

934
00:38:45,900 --> 00:38:41,650
and this shows and it's circular because

935
00:38:48,540 --> 00:38:45,910
it shows the projection to the dome it

936
00:38:53,070 --> 00:38:48,550
shows the sun's the visualization of the

937
00:38:56,310 --> 00:38:53,080
solar magnetic field and applies are the

938
00:38:59,250 --> 00:38:56,320

separate surface separating the northern

939

00:39:02,030 --> 00:38:59,260

and southern parts of the solar system

940

00:39:06,120 --> 00:39:02,040

you can see that there is a huge

941

00:39:13,730 --> 00:39:06,130

simulated sort of stored is propagating

942

00:39:23,220 --> 00:39:16,770

and the solar storm is attracting a

943

00:39:26,220 --> 00:39:23,230

diverse ready the sphere then the camera

944

00:39:28,770 --> 00:39:26,230

keeps moving out and and of course it

945

00:39:33,180 --> 00:39:28,780

hurts the solar storm will create in our

946

00:39:43,290 --> 00:39:33,190

aura and mingle or quite strong as we

947

00:39:57,349 --> 00:39:49,240

we are contact the believers and move on

948

00:40:05,660 --> 00:40:02,670

see that the Saturn compared to the

949

00:40:08,760 --> 00:40:05,670

solar system is also a tiny tiny object

950

00:40:12,960 --> 00:40:08,770

centers magnetosphere which is a million

951
00:40:16,319 --> 00:40:12,970
times and we load up our planet and

952
00:40:22,840 --> 00:40:16,329
compasses the product and system and

953
00:40:34,490 --> 00:40:32,600
phenomena and after to the edge of the

954
00:40:41,570 --> 00:40:34,500
forest

955
00:40:41,580 --> 00:40:53,920
system

956
00:41:17,310 --> 00:40:56,059
and

957
00:41:22,480 --> 00:41:17,320
outside the solar system broadcasting

958
00:41:25,000 --> 00:41:22,490
its information at reverse and when you

959
00:41:30,029 --> 00:41:25,010
move even further out you will see the

960
00:41:37,479 --> 00:41:35,229
shorted into the Galactic media so when

961
00:41:39,329 --> 00:41:37,489
you are dealing with magnetospheres the

962
00:41:54,600 --> 00:41:39,339
interplanetary and interstellar medium

963
00:42:00,180 --> 00:41:57,780

and I'd like to finish with this that

964

00:42:14,680 --> 00:42:00,190

Saturn's magnetosphere is huge solar

965

00:42:19,240 --> 00:42:17,810

when we talk to young people a lot of

966

00:42:21,320 --> 00:42:19,250

times you've heard the story that

967

00:42:23,690 --> 00:42:21,330

Saturn's density which is lower than

968

00:42:25,370 --> 00:42:23,700

water if you could have a bathtub large

969

00:42:27,500 --> 00:42:25,380

enough Saturn would float so what I've

970

00:42:29,870 --> 00:42:27,510

learned tonight is that in fact Saturn

971

00:42:33,080 --> 00:42:29,880

is in a bathtub of water which is a very

972

00:42:34,340 --> 00:42:33,090

exciting fourth we have Amanda Hendricks

973

00:42:35,960 --> 00:42:34,350

who is speaking about the moons in my

974

00:42:37,250 --> 00:42:35,970

apologies again I think I just can't

975

00:42:40,100 --> 00:42:37,260

believe that one person could actually

976

00:42:42,020 --> 00:42:40,110

summarize Saturn's moons in seven

977

00:42:44,360 --> 00:42:42,030

minutes so here to do the impossible

978

00:42:50,090 --> 00:42:44,370

I have seven minutes now to talk about

979

00:42:51,560 --> 00:42:50,100

61 minutes so I have to go fast I'm

980

00:42:54,830 --> 00:42:51,570

actually just gonna talk about some of

981

00:42:56,420 --> 00:42:54,840

the highlights here and 61 is a lot of

982

00:42:58,250 --> 00:42:56,430

moves to have which is pretty crazy I

983

00:43:00,200 --> 00:42:58,260

think and it might not even be the

984

00:43:02,720 --> 00:43:00,210

latest number because it seems like it's

985

00:43:07,010 --> 00:43:02,730

increasing all the time as new moons

986

00:43:14,380 --> 00:43:07,020

um get discovered but um let me see here

987

00:43:21,830 --> 00:43:19,790

okay um okay so here's - which the

988

00:43:25,690 --> 00:43:21,840

intermediate most of Saturn's main moon

989

00:43:29,120 --> 00:43:25,700

and looks eerily like the death star of

990

00:43:30,980 --> 00:43:29,130

Tempest also as a death star s quality

991

00:43:36,800 --> 00:43:30,990

to it because both of these moons are

992

00:43:39,770 --> 00:43:36,810

dominated by giant craters Herschel on -

993

00:43:42,050 --> 00:43:39,780

and Odysseus on Tempest and then guy

994

00:43:44,360 --> 00:43:42,060

Oney is kind of the next one out a

995

00:43:47,480 --> 00:43:44,370

little bigger I should say that - and

996

00:43:51,800 --> 00:43:47,490

Tempest are quite small on our scale in

997

00:43:53,900 --> 00:43:51,810

moon because they're about the tenth of

998

00:43:55,190 --> 00:43:53,910

the size of our Earth's moon diana is a

999

00:43:58,310 --> 00:43:55,200

little bit bigger and is characterized

1000

00:43:59,960 --> 00:43:58,320

mainly by these wispy streaks here which

1001
00:44:01,400 --> 00:43:59,970
are actually series of cracks on the

1002
00:44:05,180 --> 00:44:01,410
surface and they're brighter because

1003
00:44:07,700 --> 00:44:05,190
they're big pressure water ices exposed

1004
00:44:09,710 --> 00:44:07,710
there and I should also say that all of

1005
00:44:12,110 --> 00:44:09,720
these moons are dominated by water ice

1006
00:44:14,390 --> 00:44:12,120
on their surfaces and throughout their

1007
00:44:16,160 --> 00:44:14,400
interior and this is kind of expected

1008
00:44:18,710 --> 00:44:16,170
for this part of the solar system water

1009
00:44:20,450 --> 00:44:18,720
ice is plentiful when we start to see

1010
00:44:20,770 --> 00:44:20,460
liquid water and water vapor is where

1011
00:44:23,920 --> 00:44:20,780
thin

1012
00:44:26,320 --> 00:44:23,930
get more surprising Raya is that is

1013
00:44:28,840 --> 00:44:26,330

pretty heavily cratered the largest of

1014

00:44:31,030 --> 00:44:28,850

the inner satellites and interesting in

1015

00:44:34,540 --> 00:44:31,040

its own right because it also exhibits

1016

00:44:38,230 --> 00:44:34,550

wispy terrain like Dai Oni and um you

1017

00:44:40,540 --> 00:44:38,240

know at some point in their past Rand

1018

00:44:44,530 --> 00:44:40,550

lone probably underwent some sort of

1019

00:44:46,720 --> 00:44:44,540

tectonic activity and then there's

1020

00:44:50,170 --> 00:44:46,730

Hyperion a little farther out in the

1021

00:44:52,690 --> 00:44:50,180

system looks like a spongy potato and is

1022

00:44:55,840 --> 00:44:52,700

in fact very porous which contributes to

1023

00:44:57,610 --> 00:44:55,850

its appearance and it's also reddish

1024

00:45:00,700 --> 00:44:57,620

which is a little bit different from the

1025

00:45:03,010 --> 00:45:00,710

rest of the moons and one of my

1026

00:45:05,530 --> 00:45:03,020

favorites I a pitous which is the

1027

00:45:07,810 --> 00:45:05,540

two-faced moon one hemisphere is very

1028

00:45:10,000 --> 00:45:07,820

very dark and one hemisphere is very

1029

00:45:13,350 --> 00:45:10,010

bright and so it's very bizarre and I

1030

00:45:15,400 --> 00:45:13,360

will come back to a petition a second

1031

00:45:18,040 --> 00:45:15,410

but first we'll talk a little bit about

1032

00:45:23,760 --> 00:45:18,050

some of the small moons just to give you

1033

00:45:26,410 --> 00:45:23,770

a taste Telesto Epimetheus Helene Janus

1034

00:45:29,440 --> 00:45:26,420

Prometheus and Pandora these are some of

1035

00:45:32,170 --> 00:45:29,450

the innermost moon's most of them are

1036

00:45:33,760 --> 00:45:32,180

associated with rings that Linda may

1037

00:45:35,440 --> 00:45:33,770

have mentioned already Prometheus and

1038

00:45:39,310 --> 00:45:35,450

Pandora for instance sort of Shepherd

1039

00:45:41,410 --> 00:45:39,320

that outermost ring that's very that's

1040

00:45:44,980 --> 00:45:41,420

very thin that Linda talked about and

1041

00:45:47,440 --> 00:45:44,990

and they're very small gate or tell us

1042

00:45:49,450 --> 00:45:47,450

there's only about 16 miles across from

1043

00:45:51,250 --> 00:45:49,460

Prometheus and Pandora are only about 50

1044

00:45:54,400 --> 00:45:51,260

miles across so there's a very wide

1045

00:45:57,610 --> 00:45:54,410

range of sizes and then there's a whole

1046

00:46:00,550 --> 00:45:57,620

slew of moons way out way in the outer

1047

00:46:02,800 --> 00:46:00,560

part of the system and these are more

1048

00:46:05,130 --> 00:46:02,810

readily observed and discovered by

1049

00:46:07,900 --> 00:46:05,140

actually ground-based observers and

1050

00:46:09,940 --> 00:46:07,910

they're very small irregular and and

1051
00:46:13,660 --> 00:46:09,950
have irregular orbits - they might

1052
00:46:16,270 --> 00:46:13,670
rotate in a pro grade sense so back to l

1053
00:46:17,800 --> 00:46:16,280
a piteous one of my favorites I said it

1054
00:46:18,970 --> 00:46:17,810
has one hemisphere that's very dark the

1055
00:46:22,900 --> 00:46:18,980
one that's very bright - this is

1056
00:46:23,520 --> 00:46:22,910
obviously the dark hemisphere and this

1057
00:46:34,680 --> 00:46:23,530
is

1058
00:46:36,360 --> 00:46:34,690
a mystery to a certain extent so we have

1059
00:46:38,970 --> 00:46:36,370
some ideas of the processes that are

1060
00:46:41,820 --> 00:46:38,980
happening that there might be a dust

1061
00:46:45,870 --> 00:46:41,830
source of dark material that's actually

1062
00:46:49,020 --> 00:46:45,880
coding the this hemisphere here and

1063
00:46:51,360 --> 00:46:49,030

darkening it but we also think that the

1064

00:46:53,700 --> 00:46:51,370

process of thermal segregation so the

1065

00:46:56,250 --> 00:46:53,710

movement of volatiles and water ice on

1066

00:46:59,670 --> 00:46:56,260

the surface from warm regions to cold

1067

00:47:03,240 --> 00:46:59,680

regions is very important - but we can

1068

00:47:04,920 --> 00:47:03,250

see that lapetus is a very old surface

1069

00:47:07,230 --> 00:47:04,930

it's very heavily cratered and there are

1070

00:47:10,410 --> 00:47:07,240

these giant craters that are present

1071

00:47:12,660 --> 00:47:10,420

here - and one of the very curious

1072

00:47:15,810 --> 00:47:12,670

things in the entire southern system as

1073

00:47:18,570 --> 00:47:15,820

you may have noticed is this Ridge which

1074

00:47:21,210 --> 00:47:18,580

follows the equator and it almost goes

1075

00:47:23,280 --> 00:47:21,220

all the way around this Ridge it's like

1076
00:47:27,060 --> 00:47:23,290
a theme and it makes lapetus actually

1077
00:47:31,230 --> 00:47:27,070
even look like a walnut it's very

1078
00:47:33,030 --> 00:47:31,240
bizarre and it's about maybe twelve

1079
00:47:35,220 --> 00:47:33,040
miles wide at some points and about

1080
00:47:38,340 --> 00:47:35,230
eight miles high so it's really abrupt

1081
00:47:42,950 --> 00:47:38,350
and and we don't really understand the

1082
00:47:45,210 --> 00:47:42,960
formation mechanism for that just yet so

1083
00:47:47,940 --> 00:47:45,220
the one satellite that I haven't

1084
00:47:52,650 --> 00:47:47,950
mentioned yet the biggie but it's small

1085
00:47:54,450 --> 00:47:52,660
is Enceladus and this was our view of

1086
00:47:56,640 --> 00:47:54,460
Enceladus back in the Voyager days in

1087
00:47:59,040 --> 00:47:56,650
the early 80s it looks innocuous enough

1088
00:48:02,010 --> 00:47:59,050

doesn't look like anything too much is

1089

00:48:04,170 --> 00:48:02,020

going on there but there's a couple of

1090

00:48:06,180 --> 00:48:04,180

things that um we're interesting and

1091

00:48:09,600 --> 00:48:06,190

that is that we knew that it was very

1092

00:48:12,360 --> 00:48:09,610

bright and it reflects nearly a hundred

1093

00:48:14,520 --> 00:48:12,370

percent of the light that hits it which

1094

00:48:15,810 --> 00:48:14,530

is interesting I'll tell you why but if

1095

00:48:18,660 --> 00:48:15,820

you if you think about it that's very

1096

00:48:21,660 --> 00:48:18,670

very bright because our Moon I think is

1097

00:48:23,490 --> 00:48:21,670

pretty bright and it only reflects about

1098

00:48:25,140 --> 00:48:23,500

ten percent of the light if you think

1099

00:48:27,870 --> 00:48:25,150

about something reflecting 100% of the

1100

00:48:30,210 --> 00:48:27,880

light that is bright and it's in its

1101

00:48:33,010 --> 00:48:30,220

water ice so like snow it's very bright

1102

00:48:36,520 --> 00:48:33,020

but the other curious thing that we

1103

00:48:38,470 --> 00:48:36,530

early on about Enceladus is that it

1104

00:48:42,550 --> 00:48:38,480

isn't very cratered and you can see that

1105

00:48:44,350 --> 00:48:42,560

for instance in this region here there's

1106

00:48:45,760 --> 00:48:44,360

very few craters and there's even sort

1107

00:48:49,030 --> 00:48:45,770

of this folded terrain that's

1108

00:48:52,020 --> 00:48:49,040

interesting but if if a body in the

1109

00:48:54,820 --> 00:48:52,030

solar system is not very cratered and

1110

00:48:56,530 --> 00:48:54,830

especially if it's also very bright then

1111

00:49:01,720 --> 00:48:56,540

that tells us that it's curious because

1112

00:49:03,970 --> 00:49:01,730

generally bodies moons even planets as

1113

00:49:06,160 --> 00:49:03,980

they evolve an age will tend to

1114

00:49:09,910 --> 00:49:06,170

accumulate craters and accumulate dark

1115

00:49:11,590 --> 00:49:09,920

material meteoritic bombardment and so

1116

00:49:13,330 --> 00:49:11,600

forth will create craters and add dark

1117

00:49:16,359 --> 00:49:13,340

materials so things tend to get darker

1118

00:49:19,660 --> 00:49:16,369

and more cratered and so we look at a

1119

00:49:20,920 --> 00:49:19,670

body like our moon and it's pretty dark

1120

00:49:23,680 --> 00:49:20,930

and heavily cratered and it's

1121

00:49:25,560 --> 00:49:23,690

geologically very old but this was a

1122

00:49:29,109 --> 00:49:25,570

clue that Enceladus is geologically

1123

00:49:32,890 --> 00:49:29,119

young and perhaps currently active and

1124

00:49:37,450 --> 00:49:32,900

sure enough Cassini discovered geologic

1125

00:49:39,280 --> 00:49:37,460

activity on Enceladus in well 2005 but

1126

00:49:42,099 --> 00:49:39,290

this actually came the images actually

1127

00:49:43,960 --> 00:49:42,109

came a bit later Thomas sort of alluded

1128

00:49:45,609 --> 00:49:43,970

to some of the measurements that were

1129

00:49:47,920 --> 00:49:45,619

made that actually discovered the

1130

00:49:49,450 --> 00:49:47,930

activity and this is one of the exciting

1131

00:49:51,550 --> 00:49:49,460

things about Cassini that there's 12

1132

00:49:53,650 --> 00:49:51,560

instruments on board and nearly all of

1133

00:49:56,800 --> 00:49:53,660

them contributed some little piece to

1134

00:50:00,460 --> 00:49:56,810

this whole discovery of activity on

1135

00:50:01,990 --> 00:50:00,470

Enceladus so that was pretty neat 20

1136

00:50:04,270 --> 00:50:02,000

right there's a giant plume with a South

1137

00:50:06,040 --> 00:50:04,280

Pole of Enceladus and it's made up of

1138

00:50:10,000 --> 00:50:06,050

these individual jets that you can see

1139

00:50:13,210 --> 00:50:10,010

that eject water vapor and water ice

1140

00:50:15,490 --> 00:50:13,220

grains and some other vapors such as

1141

00:50:19,210 --> 00:50:15,500

ammonia and hydrocarbons out from the

1142

00:50:20,590 --> 00:50:19,220

interior of the body so I said it's

1143

00:50:24,580 --> 00:50:20,600

centered on the South Pole the South

1144

00:50:27,580 --> 00:50:24,590

Pole is about right here and when you

1145

00:50:29,410 --> 00:50:27,590

look at the surface like this um it does

1146

00:50:32,740 --> 00:50:29,420

look interesting so it's got these what

1147

00:50:35,440 --> 00:50:32,750

so-called tiger stripes this is a kind

1148

00:50:37,300 --> 00:50:35,450

of an enhanced color image here and it

1149

00:50:39,070 --> 00:50:37,310

turns out that you know that's really

1150

00:50:41,210 --> 00:50:39,080

where all the action is there's

1151

00:50:44,870 --> 00:50:41,220

fractures on the surface

1152

00:50:47,480 --> 00:50:44,880

that are actually hot so this is from

1153

00:50:51,770 --> 00:50:47,490

the long wavelength infrared camera on

1154

00:50:53,720 --> 00:50:51,780

Cassini that is showing that you know we

1155

00:50:55,339 --> 00:50:53,730

knew going into this from the earlier

1156

00:50:57,740 --> 00:50:55,349

flybys that the South Pole had a hot

1157

00:51:00,440 --> 00:50:57,750

spot but now we actually know that heat

1158

00:51:03,950 --> 00:51:00,450

is actually coming from those fractures

1159

00:51:06,859 --> 00:51:03,960

and we also know that the Jets the Jets

1160

00:51:11,270 --> 00:51:06,869

sources are located along these hot

1161

00:51:13,580 --> 00:51:11,280

fractures so we still have questions we

1162

00:51:15,260 --> 00:51:13,590

still don't know exactly why it would

1163

00:51:17,660 --> 00:51:15,270

why would there would be this much heat

1164

00:51:21,200 --> 00:51:17,670

and what the exact source of the plume

1165

00:51:22,490 --> 00:51:21,210

is and we have a pretty good idea that

1166

00:51:26,180 --> 00:51:22,500

we need some amount of liquid water

1167

00:51:28,520 --> 00:51:26,190

under the surface but how could how that

1168

00:51:31,430 --> 00:51:28,530

water can be kept liquid at such a tiny

1169

00:51:33,050 --> 00:51:31,440

body and so far out in the solar system

1170

00:51:37,190 --> 00:51:33,060

where everything should just be frozen

1171

00:51:39,290 --> 00:51:37,200

it's really quite a good mystery so the

1172

00:51:42,560 --> 00:51:39,300

plume extends very high we've seen this

1173

00:51:44,480 --> 00:51:42,570

image before material a lot of the

1174

00:51:47,750 --> 00:51:44,490

material falls back onto the surface but

1175

00:51:51,560 --> 00:51:47,760

some of it is lost and ejected out into

1176

00:51:53,810 --> 00:51:51,570

the system and so a well I'll end

1177

00:51:57,320 --> 00:51:53,820

actually with this image right here that

1178

00:52:00,290 --> 00:51:57,330

shows the effect of Enceladus and its

1179

00:52:03,859 --> 00:52:00,300

activity it actually creates the e-ring

1180

00:52:07,820 --> 00:52:03,869

that Linda and I think Kevin showed very

1181

00:52:11,210 --> 00:52:07,830

nice images of that is a giant ring in a

1182

00:52:14,030 --> 00:52:11,220

system and it actually plays an

1183

00:52:16,280 --> 00:52:14,040

important role for adding water into the

1184

00:52:20,810 --> 00:52:16,290

system that makes the Seanie and saturn

1185

00:52:22,520 --> 00:52:20,820

swim in the system and for creating an

1186

00:52:24,740 --> 00:52:22,530

environment in which the other moon's

1187

00:52:27,140 --> 00:52:24,750

orbit that affects their surface

1188

00:52:30,890 --> 00:52:27,150

composition as well and other effects -

1189

00:52:32,780 --> 00:52:30,900

so here's little Enceladus just just

1190

00:52:35,660 --> 00:52:32,790

ejecting material away and just

1191

00:52:38,750 --> 00:52:35,670

activists can be and creating this broad

1192

00:52:51,390 --> 00:52:38,760

earring so it's a fascinating object

1193

00:52:59,260 --> 00:52:54,490

lastly to talk about the king of the

1194

00:53:10,210 --> 00:52:59,270

moons I can call it that uh Saturn there

1195

00:53:11,800 --> 00:53:10,220

we are okay thank you Laura by the way I

1196

00:53:13,600 --> 00:53:11,810

like that picture you had it in the

1197

00:53:22,420 --> 00:53:13,610

introduction I was struck by how much

1198

00:53:28,050 --> 00:53:22,430

Amanda and I we are identical twins so

1199

00:53:36,340 --> 00:53:31,090

it's past my bedtime how many people are

1200

00:53:40,150 --> 00:53:36,350

up past there but I have a newsflash for

1201
00:53:43,830 --> 00:53:40,160
all of you in fact Oh someone remembers

1202
00:53:46,600 --> 00:53:43,840
the summer of 2008 there's lashes yeah

1203
00:53:49,810 --> 00:53:46,610
it's actually good and that news flash

1204
00:53:52,120 --> 00:53:49,820
is that Titan is should not be thought

1205
00:53:55,030 --> 00:53:52,130
of as a moon of Saturn it really needs

1206
00:53:57,640 --> 00:53:55,040
to be thought of as its own world it

1207
00:54:02,200 --> 00:53:57,650
really is a world and this is something

1208
00:54:04,210 --> 00:54:02,210
that Cassini and Huygens have shown us

1209
00:54:07,150 --> 00:54:04,220
one of the major discoveries of this

1210
00:54:10,570 --> 00:54:07,160
mission is in spite of the fact that

1211
00:54:14,080 --> 00:54:10,580
Titan orbits Saturn it really in in

1212
00:54:15,880 --> 00:54:14,090
always is is very much like a planet

1213
00:54:18,280 --> 00:54:15,890

it's the size of a planet it's bigger

1214

00:54:20,380 --> 00:54:18,290

than the planet Mercury it has a dense

1215

00:54:23,200 --> 00:54:20,390

atmosphere that atmosphere was actually

1216

00:54:26,440 --> 00:54:23,210

discovered almost 60 years ago from

1217

00:54:29,440 --> 00:54:26,450

telescopes on the earth and in fact in

1218

00:54:32,770 --> 00:54:29,450

this picture we very rarely get to see

1219

00:54:34,540 --> 00:54:32,780

pictures of planetary objects with stars

1220

00:54:36,460 --> 00:54:34,550

behind them this is one of the reasons

1221

00:54:38,110 --> 00:54:36,470

why some of our friends absolutely

1222

00:54:40,180 --> 00:54:38,120

insist that all these pictures have been

1223

00:54:42,100 --> 00:54:40,190

faked because there are no stars on the

1224

00:54:44,440 --> 00:54:42,110

back but in fact what you have to

1225

00:54:46,550 --> 00:54:44,450

recognize is when the sun is shining on

1226

00:54:48,650 --> 00:54:46,560

a planet or a moon or

1227

00:54:50,570 --> 00:54:48,660

whatever that light is so bright that

1228

00:54:52,760 --> 00:54:50,580

you can't capture the stars behind it

1229

00:54:55,970 --> 00:54:52,770

even in the vacuum of space the contrast

1230

00:54:59,000 --> 00:54:55,980

is just too great so Titan is shown here

1231

00:55:01,460 --> 00:54:59,010

in this image being illuminated by

1232

00:55:03,770 --> 00:55:01,470

Saturn and by Saturn's rings that's in

1233

00:55:06,170 --> 00:55:03,780

the shadow it's in eclipse it's in night

1234

00:55:08,240 --> 00:55:06,180

time and so we can see the stars behind

1235

00:55:10,730 --> 00:55:08,250

it and it's a long exposure so those

1236

00:55:12,680 --> 00:55:10,740

stars are scared a little bit but this

1237

00:55:17,930 --> 00:55:12,690

is a world that happens to be around

1238

00:55:20,060 --> 00:55:17,940

another world namely Saturn so for

1239

00:55:24,260 --> 00:55:20,070

centuries three centuries ago Titan was

1240

00:55:27,080 --> 00:55:24,270

discovered and much about it was not

1241

00:55:30,290 --> 00:55:27,090

known the atmosphere was discovered

1242

00:55:33,140 --> 00:55:30,300

fifty years ago Voyager 1 flew by in

1243

00:55:35,300 --> 00:55:33,150

1980 and found that this atmosphere is

1244

00:55:38,570 --> 00:55:35,310

very dense in fact at the surface of

1245

00:55:40,580 --> 00:55:38,580

Titan the air is four times denser than

1246

00:55:42,440 --> 00:55:40,590

the air in this room believe it or not

1247

00:55:45,530 --> 00:55:42,450

after all these talks the air may seem

1248

00:55:48,260 --> 00:55:45,540

very dense four times denser than the

1249

00:55:50,030 --> 00:55:48,270

air in this room and yet Titan is not

1250

00:55:52,340 --> 00:55:50,040

the size of the earth it's only the size

1251
00:55:54,410 --> 00:55:52,350
of mercury so it's gravity is about that

1252
00:55:57,170 --> 00:55:54,420
of our own moon it holds an atmosphere

1253
00:56:00,590 --> 00:55:57,180
because it's so far from the Sun that

1254
00:56:02,170 --> 00:56:00,600
everything is cold it's minus 290

1255
00:56:05,350 --> 00:56:02,180
Fahrenheit at the surface and that

1256
00:56:08,540 --> 00:56:05,360
allows Titan to hold on to an atmosphere

1257
00:56:10,580 --> 00:56:08,550
where as bodies about the same size for

1258
00:56:12,680 --> 00:56:10,590
example mercury could not do that

1259
00:56:15,830 --> 00:56:12,690
because mercury is just too close to the

1260
00:56:19,700 --> 00:56:15,840
Sun but the surface of Titan has been a

1261
00:56:21,800 --> 00:56:19,710
mystery and it was finally revealed in a

1262
00:56:24,350 --> 00:56:21,810
way that is really spectacular one of

1263
00:56:27,050 --> 00:56:24,360

the things about this mission is that

1264

00:56:29,900 --> 00:56:27,060

Cassini has the capability to smell and

1265

00:56:32,960 --> 00:56:29,910

taste as well as to see things but it

1266

00:56:35,570 --> 00:56:32,970

also actually deployed a very very heavy

1267

00:56:38,300 --> 00:56:35,580

and complex probe called coils which was

1268

00:56:40,370 --> 00:56:38,310

built by the European Space Agency which

1269

00:56:43,520 --> 00:56:40,380

actually descended to the surface of

1270

00:56:47,130 --> 00:56:43,530

Titan and it carried a son symphonic

1271

00:56:52,810 --> 00:56:49,720

and haven't your trip of several weeks

1272

00:56:55,540 --> 00:56:52,820

in January of 2005

1273

00:56:57,850 --> 00:56:55,550

if plunged at hypersonic speed into the

1274

00:57:00,640 --> 00:56:57,860

atmosphere of Titan landed on the

1275

00:57:02,710 --> 00:57:00,650

surface took images made chemical

1276
00:57:05,020 --> 00:57:02,720
measurements that boy that one by fast

1277
00:57:08,380 --> 00:57:05,030
let's do that on my computer ok well

1278
00:57:10,930 --> 00:57:08,390
that's good so if you put together all

1279
00:57:12,910 --> 00:57:10,940
of the images that the Huygens probe

1280
00:57:15,670 --> 00:57:12,920
took is it parachuted through the

1281
00:57:18,820 --> 00:57:15,680
atmosphere you see this very strange

1282
00:57:21,850 --> 00:57:18,830
surreal landscape and this is actually a

1283
00:57:24,430 --> 00:57:21,860
mosaic of images that averaged out to an

1284
00:57:26,140 --> 00:57:24,440
altitude of between thirty and forty

1285
00:57:28,750 --> 00:57:26,150
thousand feet so this is really a

1286
00:57:30,610 --> 00:57:28,760
jetliner view of the region of Titan

1287
00:57:34,300 --> 00:57:30,620
where the plugins probe landed the probe

1288
00:57:36,820 --> 00:57:34,310

actually landed just about in here these

1289

00:57:40,000 --> 00:57:36,830

are dune fields in the background about

1290

00:57:43,690 --> 00:57:40,010

15 miles away and yes the air is very

1291

00:57:45,430 --> 00:57:43,700

very hazy and cloudy the dune fields are

1292

00:57:47,140 --> 00:57:45,440

not dunes of sand they're dunes of

1293

00:57:49,300 --> 00:57:47,150

organic material we know that from

1294

00:57:52,150 --> 00:57:49,310

instruments on the Cassini orbiter this

1295

00:57:54,190 --> 00:57:52,160

is a hill of ice that's about a thousand

1296

00:57:56,380 --> 00:57:54,200

feet high not a very impressive mountain

1297

00:57:58,270 --> 00:57:56,390

but there aren't very many mountains on

1298

00:58:00,250 --> 00:57:58,280

Titan and then there are these

1299

00:58:03,100 --> 00:58:00,260

interesting landforms that are actually

1300

00:58:05,890 --> 00:58:03,110

debris fields of material that has come

1301

00:58:09,670 --> 00:58:05,900

down from these hills and in fact with

1302

00:58:11,380 --> 00:58:09,680

images that are higher resolution from

1303

00:58:14,020 --> 00:58:11,390

the camera on the Logans probe we see

1304

00:58:16,900 --> 00:58:14,030

fracture systems that seem to be filled

1305

00:58:19,150 --> 00:58:16,910

with some dark material we see these

1306

00:58:20,890 --> 00:58:19,160

valley networks that are small this is

1307

00:58:22,810 --> 00:58:20,900

an area a couple of miles across and

1308

00:58:25,090 --> 00:58:22,820

then down at the landing site these

1309

00:58:27,010 --> 00:58:25,100

rounded pebbles when you put all of

1310

00:58:30,340 --> 00:58:27,020

these things together what you realize

1311

00:58:34,900 --> 00:58:30,350

is that this landscape has been modified

1312

00:58:36,880 --> 00:58:34,910

by flowing liquid now minus 290

1313

00:58:40,500 --> 00:58:36,890

Fahrenheit it's not going to be liquid

1314

00:58:43,270 --> 00:58:40,510

water right because water freezes at 32

1315

00:58:45,680 --> 00:58:43,280

into the instrument and there's even a

1316

00:58:49,069 --> 00:58:45,690

dew drop of methane formed on the

1317

00:58:51,400 --> 00:58:49,079

so methane is carving these channels

1318

00:58:54,589 --> 00:58:51,410

welling up through these fractures and

1319

00:58:56,990 --> 00:58:54,599

through these river systems tumbling and

1320

00:58:59,960 --> 00:58:57,000

smoothing these rocks probably rocks of

1321

00:59:03,410 --> 00:58:59,970

water ice down by the landing site and

1322

00:59:05,230 --> 00:59:03,420

so whereas we have a water hydrologic

1323

00:59:07,520 --> 00:59:05,240

cycle on the earth there's a methane

1324

00:59:09,289 --> 00:59:07,530

hydrologic cycle on Titan now where's

1325

00:59:11,210 --> 00:59:09,299

all this methane coming from well we

1326

00:59:14,480 --> 00:59:11,220

don't know but one of the other

1327

00:59:17,089 --> 00:59:14,490

important discoveries by Cassini now

1328

00:59:19,279 --> 00:59:17,099

from the orbiter was of a series of

1329

00:59:21,260 --> 00:59:19,289

lakes at the South Pole and the North

1330

00:59:24,170 --> 00:59:21,270

Pole of Titan this is the North Pole of

1331

00:59:27,109 --> 00:59:24,180

Titan the background image is the camera

1332

00:59:29,779 --> 00:59:27,119

system on Cassini the foreground images

1333

00:59:32,240 --> 00:59:29,789

are strips from a radar system which

1334

00:59:33,950 --> 00:59:32,250

also emphasized the International aspect

1335

00:59:37,520 --> 00:59:33,960

of this mission because the radar is a

1336

00:59:41,859 --> 00:59:37,530

joint us Italian experiment that was

1337

00:59:46,160 --> 00:59:41,869

built as my alarm it's time to go to bed

1338

00:59:48,559 --> 00:59:46,170

and so what the radar system which was

1339

00:59:50,870 --> 00:59:48,569

built by Ozzie and Italy of JPL here in

1340

00:59:54,260 --> 00:59:50,880

the US revealed where these dark areas

1341

00:59:56,240 --> 00:59:54,270

very very dark very smooth in a

1342

00:59:59,180 --> 00:59:56,250

landscape which looks like it's been

1343

01:00:01,430 --> 00:59:59,190

carved again by channels and all of the

1344

01:00:04,309 --> 01:00:01,440

evidence that we have from the

1345

01:00:06,829 --> 01:00:04,319

instruments on Cassini is that these are

1346

01:00:08,930 --> 01:00:06,839

filled with liquid that they are basins

1347

01:00:11,029 --> 01:00:08,940

filled with liquid the dark areas the

1348

01:00:12,980 --> 01:00:11,039

biggest ones the biggest one in fact is

1349

01:00:15,319 --> 01:00:12,990

larger than the Caspian Sea on the earth

1350

01:00:19,640 --> 01:00:15,329

the smaller ones you see here are a few

1351
01:00:21,680 --> 01:00:19,650
miles across and unfortunately we can't

1352
01:00:24,140 --> 01:00:21,690
go and touch them and taste them logan's

1353
01:00:26,960 --> 01:00:24,150
probe ended up at the equator these are

1354
01:00:28,940 --> 01:00:26,970
at the poles but we're getting more and

1355
01:00:31,400 --> 01:00:28,950
more data from Cassini on these lakes

1356
01:00:34,000 --> 01:00:31,410
and seas here's one that's in the

1357
01:00:37,039 --> 01:00:34,010
southern hemisphere called Ontario lacus

1358
01:00:38,900 --> 01:00:37,049
which is Latin for Lake Ontario it's

1359
01:00:42,079 --> 01:00:38,910
just about the size of Lake Ontario

1360
01:00:44,630 --> 01:00:42,089
about 170 miles long here's an image

1361
01:00:46,730 --> 01:00:44,640
from the Cassini camera in 2004 now

1362
01:00:49,880 --> 01:00:46,740
watch this image because I'm going to

1363
01:00:52,440 --> 01:00:49,890

switch to a radar image that was taken

1364

01:00:56,610 --> 01:00:52,450
in 2009 five years

1365

01:00:58,530 --> 01:00:56,620
and not only do you see a bit more

1366

01:01:01,230 --> 01:00:58,540
clarity with the radar because it

1367

01:01:05,330 --> 01:01:01,240
penetrates the haze but you also notice

1368

01:01:08,220 --> 01:01:05,340
that the lake has gotten smaller now I

1369

01:01:10,080 --> 01:01:08,230
think and many other my colleagues think

1370

01:01:11,640 --> 01:01:10,090
this is not just in an instrumental

1371

01:01:13,890 --> 01:01:11,650
effect the lake really has gotten

1372

01:01:15,990 --> 01:01:13,900
smaller and why is it gotten smaller

1373

01:01:17,910 --> 01:01:16,000
well in Southern California were used to

1374

01:01:21,690 --> 01:01:17,920
Lakes drying out right you do that only

1375

01:01:23,430 --> 01:01:21,700
time so nothing special in this case the

1376

01:01:27,170 --> 01:01:23,440

southern hemisphere has been in sunlight

1377

01:01:30,600 --> 01:01:27,180

by the time this picture was taken for

1378

01:01:34,500 --> 01:01:30,610

about almost half a Titan orbit 14 years

1379

01:01:36,360 --> 01:01:34,510

it's been through summer Saturn as it

1380

01:01:39,360 --> 01:01:36,370

orbits the Sun has a year that's about

1381

01:01:41,730 --> 01:01:39,370

29 and a half years long so that's the

1382

01:01:43,730 --> 01:01:41,740

year on Titan each season then is a

1383

01:01:46,800 --> 01:01:43,740

little bit more than seven years long

1384

01:01:50,040 --> 01:01:46,810

Cassini arrived in the summer and from

1385

01:01:52,680 --> 01:01:50,050

2004 to 2009 the Sun has been shining on

1386

01:01:54,360 --> 01:01:52,690

these lakes and so we expect this should

1387

01:01:56,730 --> 01:01:54,370

be evaporating and the amount of

1388

01:01:59,550 --> 01:01:56,740

evaporation that one expects over five

1389

01:02:01,890 --> 01:01:59,560

years is just about right - cause the

1390

01:02:04,230 --> 01:02:01,900

shrinkage that we see in this lake in

1391

01:02:06,240 --> 01:02:04,240

fact we know what the topographic

1392

01:02:08,190 --> 01:02:06,250

profile of this lake is because there

1393

01:02:11,370 --> 01:02:08,200

are altimeter measurements from Cassini

1394

01:02:13,440 --> 01:02:11,380

so putting all that together the

1395

01:02:15,150 --> 01:02:13,450

shrinkage of this lake is consistent

1396

01:02:17,490 --> 01:02:15,160

with it being methane and that methane

1397

01:02:19,200 --> 01:02:17,500

is being transported from the South Pole

1398

01:02:21,630 --> 01:02:19,210

to the North Pole now that's not all

1399

01:02:24,120 --> 01:02:21,640

that's in this lake there's a sister

1400

01:02:26,550 --> 01:02:24,130

molecule - methane which is a simple

1401

01:02:29,340 --> 01:02:26,560

organic molecule made of four hydrogen's

1402

01:02:31,680 --> 01:02:29,350

and one carbon its sister molecule is

1403

01:02:34,560 --> 01:02:31,690

called ethane two carbons and six

1404

01:02:36,750 --> 01:02:34,570

hydrogen's it mixes with methane but

1405

01:02:39,660 --> 01:02:36,760

doesn't evaporate the way that methane

1406

01:02:41,940 --> 01:02:39,670

does it gets left behind and ethane was

1407

01:02:43,830 --> 01:02:41,950

actually directly detected by one of the

1408

01:02:47,040 --> 01:02:43,840

Cassini instruments by was called the

1409

01:02:50,160 --> 01:02:47,050

vim spectrometer in Lake Ontario

1410

01:02:50,880 --> 01:02:50,170

so these lakes contain two kinds of

1411

01:02:53,460 --> 01:02:50,890

liquids

1412

01:02:55,260 --> 01:02:53,470

methane and ethane it would be like the

1413

01:02:57,600 --> 01:02:55,270

lakes and oceans on the earth containing

1414

01:02:59,820 --> 01:02:57,610

two kinds of water evaporating water and

1415

01:03:01,860 --> 01:02:59,830

still water but we don't actually have

1416

01:03:05,310 --> 01:03:01,870

that there's no real analogy for that on

1417

01:03:08,340 --> 01:03:05,320

the earth so Titan is Lakes it has

1418

01:03:11,610 --> 01:03:08,350

rivers it has clouds there's evidence

1419

01:03:14,220 --> 01:03:11,620

for rain not only then is Titan one of

1420

01:03:17,580 --> 01:03:14,230

four solid worlds with dense atmospheres

1421

01:03:19,380 --> 01:03:17,590

along with Venus Mars and Earth but it's

1422

01:03:22,140 --> 01:03:19,390

one of only two solid bodies in the

1423

01:03:24,030 --> 01:03:22,150

solar system which have open bodies of

1424

01:03:26,670 --> 01:03:24,040

liquid on their surfaces and therefore

1425

01:03:28,710 --> 01:03:26,680

how the hydrologic cycle and the earth

1426

01:03:30,990 --> 01:03:28,720

is the other one and so for that reason

1427

01:03:35,010 --> 01:03:31,000

we really have to think of Titan as a

1428

01:03:37,470 --> 01:03:35,020

complete and dynamic world so what is

1429

01:03:39,990 --> 01:03:37,480

the future for studying this hydrologic

1430

01:03:42,720 --> 01:03:40,000

system well we are now as you've heard

1431

01:03:45,150 --> 01:03:42,730

at this magic point called Equinox which

1432

01:03:49,230 --> 01:03:45,160

means equal night equal day and night on

1433

01:03:51,510 --> 01:03:49,240

Saturn and Titan that means that the Sun

1434

01:03:53,880 --> 01:03:51,520

has set over the southern polar region

1435

01:03:55,740 --> 01:03:53,890

and the Sun is now beginning to appear

1436

01:03:58,560 --> 01:03:55,750

over the horizon in the north polar

1437

01:04:01,050 --> 01:03:58,570

region where you saw those radar images

1438

01:04:02,910 --> 01:04:01,060

and now the hope is we can begin to see

1439

01:04:04,490 --> 01:04:02,920

the lakes which are actually bigger in

1440

01:04:07,950 --> 01:04:04,500

the northern hemisphere region

1441

01:04:10,920 --> 01:04:07,960

themselves begin to evaporate as we move

1442

01:04:13,290 --> 01:04:10,930

from equinox towards solstice over this

1443

01:04:16,440 --> 01:04:13,300

long seven-year period of what is

1444

01:04:18,180 --> 01:04:16,450

northern hemisphere spring and so

1445

01:04:21,690 --> 01:04:18,190

Cassini will undoubtedly show us

1446

01:04:23,700 --> 01:04:21,700

surprising changes weather and so on in

1447

01:04:25,620 --> 01:04:23,710

the Lakes region in the North we'll

1448

01:04:28,440 --> 01:04:25,630

learn something about how climate works

1449

01:04:30,870 --> 01:04:28,450

on this world a very exotic world where

1450

01:04:34,410 --> 01:04:30,880

rivers of methane run down to a sunless

1451

01:04:36,300 --> 01:04:34,420

sea as alien as any world you could

1452

01:04:39,030 --> 01:04:36,310

imagine in Star Trek or Star Wars

1453

01:04:41,010 --> 01:04:39,040

certainty so a wonderful place to visit