



1
00:00:06,607 --> 00:00:12,946
>>> JET PROPULSION LABORATORY

2
00:00:12,946 --> 00:00:18,151
PRESENTS THE VON KARMAN LECTURE,
AND ENGINEERS ARE FLOORING TESTS

3
00:00:18,151 --> 00:00:47,414
OUR PLANET, OUR SOLAR SYSTEM AND
ALL THAT IS BEYOND.

4
00:00:47,414 --> 00:00:47,981
>>> HELLO, EVERYONE.

5
00:00:47,981 --> 00:00:56,123
AND THANK YOU FOR COMING TO JPL
FOR THIS VON KARMAN LECTURE ON

6
00:00:56,123 --> 00:00:58,825
A CHILLY NOVEMBER EVENING.

7
00:00:58,825 --> 00:01:02,696
WE ARE HERE TO LEARN ABOUT THE
JUNO MISSION TO JUPITER.

8
00:01:02,696 --> 00:01:10,904
4th, INDEPENDENCE DAY, 2016. JULY
JUPITER IS BY FAR THE LARGEST

9
00:01:10,904 --> 00:01:16,410
PLANET IN OUR SOLAR SYSTEM.
PLANET IN OUR SOLAR SYSTEM.

10
00:01:16,410 --> 00:01:18,812
IT HAS MORE MASS THAN TWICE THE MASS
OF ALL THE OTHER PLANETS

11
00:01:18,812 --> 00:01:19,179
COMBINED.

12
00:01:19,179 --> 00:01:23,383
IT ALMOST CERTAINLY WAS THE VERY
FIRST PLANET TO FORM AND

13
00:01:23,383 --> 00:01:25,819
UNDERSTANDING ITS FORMATION IS A
KEY TO UNDERSTANDING OUR VERY

14
00:01:25,819 --> 00:01:31,091
OWN SOLAR SYSTEM.

15
00:01:31,091 --> 00:01:36,196
SO TONIGHT'S GUEST IS THE
PROJECT SCIENTIST FOR THE JUN

16
00:01:36,196 --> 00:01:40,734
MISSION, STEVE LEVIN.

17
00:01:40,734 --> 00:01:47,541
HE RECEIVED A Ph.D. IN PHYSICS
FROM UNIVERSITY OF CALIFORNIA IN

18
00:01:47,541 --> 00:01:48,041
BERKELEY IN 1977.

19
00:01:48,041 --> 00:01:53,113
HE WORKED AS RESEARCH PHYSICIST
UNTIL 1990 WHEN HE CAME TO JPL.

20
00:01:53,113 --> 00:01:57,784
HIS INTERESTS HAVE INCLUDED
MEASUREMENTS OF THE COSMIC

21
00:01:57,784 --> 00:02:02,089
MICROWAVE BACKGROUND RADIATION,
THE SEARCH FOR INTELLIGENCE,

22
00:02:02,089 --> 00:02:08,962

MEASUREMENTS OF STAR FORMING
REGIONS AND MODELING OF THE

- 23
00:02:08,962 --> 00:02:14,668
INTERJOVIAN RADIATION BELT.çóçó
HE'S DONE RADIO ASTRONOMY WITH
- 24
00:02:14,668 --> 00:02:19,873
INSTRUMENTS ON MNTAINTOPS, AT
THE SOUTH POLE, ON LARGE RADIO
- 25
00:02:19,873 --> 00:02:22,776
TELESCOPES, ON HIGH ALTITUDE
BALLOON AND ON SPACECRAFT.
- 26
00:02:22,776 --> 00:02:29,082
HE HAS PUBLISHED DOZENS OF
PAPERS AND WON NUMEROUS AWARDS

27
00:02:29,082 --> 00:02:33,220
INCLUDING A NASA EXCEPTION
ACHIEVEMENTñr MEDAL IN 2012.

28
00:02:33,220 --> 00:02:34,788
HE LITERALLY -- I HAVE TO TELL
YOU, HE LITERALLY JUMPED ON A

29
00:02:34,788 --> 00:02:41,061
PLANE AND FLEW HOMEñi LAST NIGH
JUST TO BE HERE.

30
00:02:41,061 --> 00:02:44,531
HE FLEWñi HOME FROM A SCIENCE
MEETING IN MARYLAND.

31
00:02:44,531 --> 00:02:47,467
PLEASE JOIN ME IN GIVING STEVE
LEVIN A VERY WARM WELCOME.ñr

32
00:02:47,467 --> 00:02:56,710

[APPUSE]
>> THANK YOU.

33
00:02:56,710 --> 00:03:02,382
IS THE MIC WORKING?

34
00:03:02,382 --> 00:03:03,417
WELL, LET'S SEE -- NOW IT'S
WORKING.

35
00:03:03,417 --> 00:03:03,784
TERRIFIC.

36
00:03:03,784 --> 00:03:04,351
THANK YOU.

37
00:03:04,351 --> 00:03:04,651
OKAY.

38
00:03:04,651 --> 00:03:10,390
SO AFTER THAT INTRODUCTION I
FEEL I MUST BE IMPORTANT OR

39
00:03:10,390 --> 00:03:14,428
SOMETHING.

40
00:03:14,428 --> 00:03:17,230
I'MxD GOING TO TELL YOU ABOUT
JUNO.

41
00:03:17,230 --> 00:03:19,132
WHICH IS ON ITS WAY TO JUPITER.

42
00:03:19,132 --> 00:03:22,836
AND AS YOU JUST HEARD GETS THERE
ON THE 4th OF JULY.

43
00:03:22,836 --> 00:03:27,808
ITñrÑiÑi REALLY GETS THERE ON T

OF JULY UNIVERSAL TIME.

44

00:03:27,808 --> 00:03:30,444

THAT'S HOW WE USUALLY COUNT
THINGS IN GREENWICH ENGLAND.

45

00:03:30,444 --> 00:03:34,548

BUT HERE IN CALIFORNIA IT WILL
BE 4th OF JULY IN THE EVENING,

46

00:03:34,548 --> 00:03:39,653

SO FIRE WORKS FROM THE
SPACECRAFT AT THE SAME TIMEcCÑç

47

00:03:39,653 --> 00:03:40,187

HAVE FIREWORKS HERE.

48

00:03:40,187 --> 00:03:46,693

WELL, WHAT IS JUNO, WHAT ARE WE
DOING HERE?

49

00:03:46,693 --> 00:03:50,630

THE JUNO SPACECRAFT, FIRST OF
ALL, IT'S THE FIRST SOLAR

50

00:03:50,630 --> 00:03:52,866

POWERED MISSIONxD TO JUPITER.

51

00:03:52,866 --> 00:03:55,435

FIRST SPACECRAFT TO GO OUT THATi
FAR.

52

00:03:55,435 --> 00:03:56,903

WE HAVE A BUNCH OF SCIENCES ON
IT.

53

00:03:56,903 --> 00:03:58,238

IT EIGHT OR NINE OR TEN
INSTRUMENTS AS YOU WILL SEE.

54

00:03:58,238 --> 00:04:02,609

THERE'S A LOT.ÑiÑi

I WILL -- I'M NOT GOING TO READ

55

00:04:02,609 --> 00:04:03,110

THIS WHOLE THING.

56

00:04:03,110 --> 00:04:07,647

I WILL TELL YOU ABOUT WHAT WE'LL

MEASURE IN A LITTLE WHILE.

57

00:04:07,647 --> 00:04:09,783

BUT IT'S A SPINNING POLAR

ORBITER THAT WE LAUNCHED IN

58

00:04:09,783 --> 00:04:13,386

AUGUST 5, 2011.

59

00:04:13,386 --> 00:04:14,821

AND IT TAKES FIVE YEARS TO GET

TO JUPITER, BUT IT'S FINALLY

60

00:04:14,821 --> 00:04:17,324

GETTING THERE, WE'LL LEARN A LOT

ABOUT JUPITER AND THAT WILL

61

00:04:17,324 --> 00:04:20,627

TEACH US A LOT ABOUT THE SOLAR

SYSTEM AND HOW PLANETS FORM AND

62

00:04:20,627 --> 00:04:24,498

THINGS LIKE THAT.

63

00:04:24,498 --> 00:04:25,165

I SEE, I HAVE A TYPO HERE.

64

00:04:25,165 --> 00:04:29,336

IT'S A 14-DAY ORT.

65
00:04:29,336 --> 00:04:32,606
WE'LL TALK ABOUT THAT IN A
LITTLE BIT.

66
00:04:32,606 --> 00:04:35,108
IT'S A MASSIVE NEW FRONTIERS
PROGRAM.

67
00:04:35,108 --> 00:04:37,344
YOU CAN READ THE SCIENCE
OBJECTIVES THAT I'M GOING TO

68
00:04:37,344 --> 00:04:40,914
TALK ABOUT -- I'LL TALK ABOUT
THEM TOO, SO I WON'T READ THAT.

69
00:04:40,914 --> 00:04:42,516
I'LL TRY TO RUSH THROUGH THE
SLIDES TO GET TO QUESTIONS

70
00:04:42,516 --> 00:04:43,950
BECAUSE THEY'RE THE MOST FUN
PART BUT I HAVE TO MENTION THAT

71
00:04:43,950 --> 00:04:49,790
THIS ISN'T A P.I. LED MISSION. IT
THAT IS THERE'S A PRINCIPAL

72
00:04:49,790 --> 00:04:51,191
INVESTIGATOR, SCOTT BOLTON,
WHO'S IN CHARGE OF THE ENTIRE

73
00:04:51,191 --> 00:04:51,525
THING.

74
00:04:51,525 --> 00:05:00,634
THEN DELEGATES THAT AUTHORITY TO
A PROJECT MANAGER, A WHOLE TEAM

75

00:05:00,634 --> 00:05:05,939
OF PEOPLE HERE AT JPL AND A
NUMBER OF INSTITUTIONS AROUND

76
00:05:05,939 --> 00:05:06,339
THE WORLD.

77
00:05:06,339 --> 00:05:09,209
AN AT THE TIME THIS WAS THIS WAS
SELECTED IT WAS THE LARGEST P.I.

78
00:05:09,209 --> 00:05:10,911
MISSION THAT NASA HAD DONE.

79
00:05:10,911 --> 00:05:14,181
IF IT'S BIG ENOUGH IT'S SORT OF
RUN BY COMMITTEE.

80
00:05:14,181 --> 00:05:19,853
IN OUR CASE, AT LEAST, I THINK
IT WORKED OUT REALLY WELL.

81
00:05:19,853 --> 00:05:20,854
THAT THEY CHOSE TO DO IT THAT
WAY.

82
00:05:20,854 --> 00:05:27,327
WE HAVE AN EFFICIENT TEAM AND
WE'REñr REALLY WORKING WELL

83
00:05:27,327 --> 00:05:27,694
TOGETHER.

84
00:05:27,694 --> 00:05:28,895
I'M PLEASED THAT NASA CHOSE TO
DO IT THAT WAY.

85
00:05:28,895 --> 00:05:29,196
OKAY.

86
00:05:29,196 --> 00:05:30,497
SO HOW DO WE GET THERE?

87
00:05:30,497 --> 00:05:31,665
THAT'S THE PLACE TO START.

88
00:05:31,665 --> 00:05:37,704
TO BEGIN WITH WE LAUNCHED THE
SPACECRAFT WITHOUT ENOUGH ENERGY

89
00:05:37,704 --> 00:05:44,744
TO GET TO JUPITER THAT'S BECAUSE
WE DIDN'T HAVE A BIG ENOUGH

90
00:05:44,744 --> 00:05:45,912
ROCKET THAT YOU COULD GO DIRECT
TO JUPITER.

91
00:05:45,912 --> 00:05:47,147
SO THE IDEA IS YOU LAUNCH IT
FROM THE EARTH.

92
00:05:47,147 --> 00:05:50,283
WE TOOK ADVANTAGE OF EVERYTHING
WE COULD WITH THE EARTH, SPIN,

93
00:05:50,283 --> 00:05:54,888
THE SPACECRAFT, THE ROCKET AND
ALL THAT STUFF.

94
00:05:54,888 --> 00:05:56,323
THAT PUT IT INTO THE ORBIT
AROUND THE SUN.

95
00:05:56,323 --> 00:05:58,925
THAT WENT OUT SOMEWHERE PAST THE
ORBIT OF ρMARS.

96
00:05:58,925 --> 00:06:04,564

THEN WHEN WE'RE OUT THERE, WE
FIRED THE MAIN ENGINE TWICE TO

97

00:06:04,564 --> 00:06:06,333

AIM, SO THAT WE CAME BACK TO
EARTH.

98

00:06:06,333 --> 00:06:09,236

AND THE REASON FOR DOING THAT,
WHICH WE DID IN OCTOBER OF 2013

99

00:06:09,236 --> 00:06:14,374

WAS TO USE THE EARTH'S GRAVITY
A SLINGSHOT AND GET EXTRA --

100

00:06:14,374 --> 00:06:18,078

AN EXTRA BOOST AND THIS FINALLY
GAVE US ENOUGH ENERGY TO GO T

101

00:06:18,078 --> 00:06:18,545

THEñr JUPITER.

102

00:06:18,545 --> 00:06:19,679

SO WE'RE IN THE FINAL COASTING
PHASE NOW.

103

00:06:19,679 --> 00:06:28,588

WE'LL GET TO JUPITER ON 4th OF
JULY AND SLOW IT DOWN SO WE

104

00:06:28,588 --> 00:06:29,122

DON'T BLOW ON PAST.

105

00:06:29,122 --> 00:06:30,624

THAT'S THE SCARIEST TIME OF THE
WHOLE MISSION, BECAUSE YOU HAVE

106

00:06:30,624 --> 00:06:43,203

TO MAKE THE MAIN ENGINE WORK,
YOU HAVE TO MAKE THE SPACECRAFT

107

00:06:43,203 --> 00:06:47,240

FIRE THE MAIN ENGINE AT THE
RIGHT TIME SO YOU SLOW DOWN AND

108

00:06:47,240 --> 00:06:47,674

ORBIT JUPITER.

109

00:06:47,674 --> 00:06:49,142

IT DOESN'T HELP TO GET IT ALL
FIGURED OUT AND HAVE A PROBLEM

110

00:06:49,142 --> 00:06:50,677

AND SOLVE THE PROBLEM AND FIRE
IT HALF AN HOUR LATER BECAUSE BY

111

00:06:50,677 --> 00:06:51,311

THAT TIME IT'S TOO LATE.

112

00:06:51,311 --> 00:06:52,812

YOU DON'T GET INTO ORBIT.

113

00:06:52,812 --> 00:06:56,950

SO THAT'S WHY IT'S CRITICAL
EVENT.

114

00:06:56,950 --> 00:06:58,418

AND WE'LL BE BITING OUR NAILS A
LITTLE BIT ON THE 4th OF JULY.

115

00:06:58,418 --> 00:07:03,857

ALTHOUGH CROSS YOUR FINGERS I'M
SE EVERYTHING WILL WORK GREAT.

116

00:07:03,857 --> 00:07:04,257

ALL RIGHT.

117

00:07:04,257 --> 00:07:05,659

BY NOW YOU SHOULD BE ASKING

YOURSELF WHY ARE WE DOING THIS?

118

00:07:05,659 --> 00:07:15,368

AND THE ANSWER IS THAT EVEN
THOUGH JUPITER IS THE LARGEST

119

00:07:15,368 --> 00:07:21,908

PLANET IN THE SOLAR SYSTEM BY
FAR, TWICE AS BIG AS THE OTHERS,

120

00:07:21,908 --> 00:07:23,343

TWICE AS MUCH MASS AND EVEN
THOUGH WE HAVE BEEN STUDYING IT

121

00:07:23,343 --> 00:07:24,878

LITERALLY FOR HUNDREDS OF YEARS
IT'S ONE OF THE FIRST THINGS

122

00:07:24,878 --> 00:07:26,246

THAT ANYBO EVER LOOKED AT IN
THE SKY WITH A TELESCOPE.

123

00:07:26,246 --> 00:07:38,124

AND EVEN THOUGHñrÑi YOU CAN SEE
FROM THE EARTH AND WE HAVE HAD i

124

00:07:38,124 --> 00:07:43,063

SPACECRAFT THERE, MORE THAN ONE
SPACECRAFT HAS GONE BY AND GAL

125

00:07:43,063 --> 00:07:46,966

ALLAY -- GALILEO SPENT A LOT
TIME IN THE JOVIAN SYSTEM, BUT

126

00:07:46,966 --> 00:07:49,202

WE HAVE LOTS OF QUESTIONS ABOUT
JUPITER.

127

00:07:49,202 --> 00:07:53,840

WHEN YOU LOOK AT JUPITER YOU SEE

THE TOPS OF THE CLOUDS IN

128

00:07:53,840 --> 00:07:54,574

JUPITER'S ENORMOUS ATMOSPHERE.

129

00:07:54,574 --> 00:08:01,348

WE HAVE BASIC COMPOSITION, WHAT
MADE OUT OF?

130

00:08:01,348 --> 00:08:11,091

WE KNOW IT'S HYDROGEN, BUT THE
MOST COMMON ELEMENT IS OXYGEN,

131

00:08:11,091 --> 00:08:15,729

AND WE DON'T KNOW HOW MUCH THERE
IS AT JUPITER.

132

00:08:15,729 --> 00:08:18,732

WE THINK THAT'S A DENSE CORE
BETWEEN 3 AND 20 TIMES THE MASS

133

00:08:18,732 --> 00:08:22,969

OF THE EARTH BUT WE HAVE NO
DIRECT EVIDENCE THAT IT EXISTS

134

00:08:22,969 --> 00:08:23,570

LET ALONE HOW BIG IT IS.

135

00:08:23,570 --> 00:08:28,308

WE SEE A GIANT AURORA IN THE
UPPER ATMOSPHERE.

136

00:08:28,308 --> 00:08:33,079

NORTHERN AND SOUTHERN LIGHTS
LIKE THE AURORA HERE ON THE

137

00:08:33,079 --> 00:08:33,413

EARTH.

138

00:08:33,413 --> 00:08:33,880
ENORMOUSLY BIGGER.

139

00:08:33,880 --> 00:08:35,348
WE DON'T REALLY UNDERSTAND
EXACTLY HOW THAT WORKS AND THE

140

00:08:35,348 --> 00:08:37,517
MECHANISMS THAT POWER THEM.

141

00:08:37,517 --> 00:08:39,452
WE KNOW THE GENERAL IDEA.

142

00:08:39,452 --> 00:08:40,587
JUPITER HAS AN ENORMOUS MAGNETIC
FIELD.

143

00:08:40,587 --> 00:08:42,021
THE STRONGEST BY FAR OF ANY
PLANET IN THE SOLAR SYSTEM AND

144

00:08:42,021 --> 00:08:48,795
WE THINK ACTUALLY THAT THAT
MAGNETIC FIELD COMES FROM AN

145

00:08:48,795 --> 00:08:52,298
OCEAN OF LIQUID METALLIC
HYDROGEN DEEP INSIDE THE PLANET

146

00:08:52,298 --> 00:08:57,070
BUT THE DETAILS OF HOW YOU FORM
THAT MAGNETIC FIELD OR HOW YOU

147

00:08:57,070 --> 00:08:58,371
FORM A MAGNETIC FIELD IS STILL
A BIT OF A MYSTERY.

148

00:08:58,371 --> 00:09:02,776
WE HOPE TO SOLVE THE MYSTERIES.

149

00:09:02,776 --> 00:09:03,543

WE HOPE TO ANSWER THE QUESTIONS.

150

00:09:03,543 --> 00:09:04,611

THAT'S WHY WE'RE SENDING A
SPACECRAFT.

151

00:09:04,611 --> 00:09:05,178

SO WHAT DO WE KNOW?

152

00:09:05,178 --> 00:09:14,354

WELL, WE KNOW FOR EXAMPLE THATÑ
JUPITER'S HOTTER ON THE INSIDE

153

00:09:14,354 --> 00:09:14,854

THAN THE OUTSIDE.

154

00:09:14,854 --> 00:09:16,322

THAT'S BECAUSE IT'S STILL
COOLING OFF 4 1/2 BILLION YEARS

155

00:09:16,322 --> 00:09:16,823

AFTER IT FORMED.

156

00:09:16,823 --> 00:09:17,891

THAT'S HOW BIG IT IS.

157

00:09:17,891 --> 00:09:23,129

WE KNOW SOMETHING ABOUT THE
TEMPERATURE PROFILE OF THE

158

00:09:23,129 --> 00:09:23,530

ATMOSPHERE.

159

00:09:23,530 --> 00:09:28,935

HOW IT COOLS OFF.

160

00:09:28,935 --> 00:09:31,404

AND THAT'LL BECOME IMPORTANT
LATER AS YOU WILL SEE, BECAUSE

161

00:09:31,404 --> 00:09:33,006
WE'LL USE THAT TO HELP US LEARN
HOW MUCH WATER THERE IS WHICH

162

00:09:33,006 --> 00:09:34,707
TELLS US THE OXYGEN CONTENT.

163

00:09:34,707 --> 00:09:41,981
WE'RE PRETTY SURE THAT DEEP
INSIDE THAT'S THIS OCEAN OF

164

00:09:41,981 --> 00:09:43,116
METALLIC HYDROGEN.

165

00:09:43,116 --> 00:09:45,752
YOU KNOW I TALK ABOUT JUNO AND
JUPITER A LOT.

166

00:09:45,752 --> 00:09:51,291
I USE THAT PHRASE ALL
9k■ THE TIME, ASE ALL

167

00:09:51,291 --> 00:09:52,859
LIQUID METALLIC HYDROGEN.

168

00:09:52,859 --> 00:09:55,028
THINK OF ALL THREE WORDS,
LIQUID, METALLIC, HYDROGEN.

169

00:09:55,028 --> 00:10:02,402
HYDROGEN IS THExD LIGHTEST ELEMNT
THERE IS.

170

00:10:02,402 --> 00:10:07,540
IF I FILL A BALLOON HERE ON
EARTH WITH IT IT WOULD FLOAT UP

171
00:10:07,540 --> 00:10:07,941
TO THE SKY.

172
00:10:07,941 --> 00:10:11,177
ON JUPITER THE CONDITIONS ARE SO
INTENSE, THE PRESSURE IS SO HIGH

173
00:10:11,177 --> 00:10:16,249
FROM■ç THE ENORMOUS GRAVITY THA
NOT ONLY HAS THAT HYDROGEN GAS

174
00:10:16,249 --> 00:10:17,717
BEEN SQUEEZED DOWN INTO THE
LIQUID, BUT SQUEEZED OF THE

175
00:10:17,717 --> 00:10:20,653
LECTRONS ARE COME OFF THE ATOMS.

176
00:10:20,653 --> 00:10:21,087
IT'S A METAL.

177
00:10:21,087 --> 00:10:30,997
IT'S THE SWIRLING MOTION OF THAT
LIQUID METALLIC HYDROGEN THAT WE

178
00:10:30,997 --> 00:10:36,302
THINK GENERATES JUPITER'S
ENORMOUS MAGNETIC FIELD.

179
00:10:36,302 --> 00:10:43,142
DOWN UNDERNEATH THAT WE THINK
THERE SHOULD BE A DENSE CORE IN

180
00:10:43,142 --> 00:10:43,743
THE CENTER OF JUPITER.

181
00:10:43,743 --> 00:10:45,078
THERE'S NO WAY WE CAN GET
ANYWHERE CLOSE ENOUGH TO

182

00:10:45,078 --> 00:10:47,714

DIRECTLY SAMPLE THAT CORE OR
EVEN METALLIC HYDROGEN LAYER

183

00:10:47,714 --> 00:10:49,215

WHICH IS A COUPLE MILLION TIMES
THE PRESSURE HERE ON THE EARTH.

184

00:10:49,215 --> 00:10:54,487

SO WE NEED TO FIGURE OUT A WAY
TO MEASURE IT INDIRECTLY.

185

00:10:54,487 --> 00:10:55,822

THAT WAS THE PUZZLE FOR JUNO.

186

00:10:55,822 --> 00:10:59,826

THAT'S WHAT WE TRIED TO DO IS
COME UP WITH A WAY TO LEARN

187

00:10:59,826 --> 00:11:06,232

ABOUT THE INTERIOR OF JUPITER
WITHOUT GOING INSIDE IT.

188

00:11:06,232 --> 00:11:10,036

I SHOULD MENTION AS WELL OF
COURSE THERE'S WEATHER USE.

189

00:11:10,036 --> 00:11:13,239

YOU SEE ON JUPITER THE UPPER
ATMOSPHERE AND CLOUDS AND

190

00:11:13,239 --> 00:11:15,141

STREAMS AND THINGS MOVING AND SO
FORTH.

191

00:11:15,141 --> 00:11:20,246

WE WANT TO GET -- WE WANT TO
PENETRATE BELOW THAT WEATHER, AT

192

00:11:20,246 --> 00:11:21,447

LEAST WE WANT TO STUDY WHAT'S
BELOW THE WEATHER.

193

00:11:21,447 --> 00:11:21,748

OKAY.

194

00:11:21,748 --> 00:11:30,957

SO ONE OF THE KEY PUZZLES ABOUT
JUPITER IS WHEN THE GALILEO

195

00:11:30,957 --> 00:11:32,592

SPACECRAFT DROPPED A PROBE IN
JUPITER, WE DROPPED IT INTO ONE

196

00:11:32,592 --> 00:11:35,495

SPOT ON JUPITER IN THE 1990s.

197

00:11:35,495 --> 00:11:36,129

MEASURED A LOT OF THINGS.

198

00:11:36,129 --> 00:11:39,799

WE LEARNED A LOT FROM GALILEO
AND FROM THE PROBE.

199

00:11:39,799 --> 00:11:41,301

BUT ONE OF THE THINGS WE FOUND
WAS A REAL PUZZLE THAT NOBODY

200

00:11:41,301 --> 00:11:41,768

HAD ANTICIPATED.

201

00:11:41,768 --> 00:11:48,875

THAT IS IF YOU TAKE THE HEAVIER
ELEMENTS IN JUPITER AND MEASURE

202

00:11:48,875 --> 00:11:53,947

HOW MUCH THERE ARE AND YOU
COMPARE THE RATIO OF THE HEAVIER

203

00:11:53,947 --> 00:11:56,149

STUFF TO HYDROGEN WHICH IS MOST
OF THE PLANET, THEN YOU TAKE IT

204

00:11:56,149 --> 00:11:59,719

AND COMPARE IT TO THE SUN.

205

00:11:59,719 --> 00:12:01,220

WELL, IF JUPITER FORMED ALL AT
ONCE FROM SAME CLOUD OF GAS AND

206

00:12:01,220 --> 00:12:07,493

DUST THAT MADE THE SUN, THEN THE
PROPORTION OF ALL THE ELEMENTS

207

00:12:07,493 --> 00:12:08,361

SHOULD BE ABOUT THE SAME.

208

00:12:08,361 --> 00:12:09,729

IF I TOOK THE RATIO OF SAY
ARGONNE TO HYDROGEN, I SHOULD

209

00:12:09,729 --> 00:12:18,304

FOUND ABOUT THE SAME RATIO IN
JUPITER AND IN THE SUN.

210

00:12:18,304 --> 00:12:22,442

OR CRYPTON OR ZENNON.

211

00:12:22,442 --> 00:12:24,377

THESE ARE MEASURED BY THE
GALILEO PROBE AND TAPE THAT

212

00:12:24,377 --> 00:12:25,044

FOUND, THEY WERE ENRICHED.

213

00:12:25,044 --> 00:12:27,347

IT WAS TWO OR THREE TIMES AS

MUCH OF THE HEAVIER ELEMENT AS

214

00:12:27,347 --> 00:12:30,883

ONE WOULD EXPECT.

215

00:12:30,883 --> 00:12:32,218

SO THAT WAS THE PUZZLE, HOW THE
HECK DID THAT HAPPEN?

216

00:12:32,218 --> 00:12:41,227

AND THEN WATER THEY FOUND ALMOST
NONE.

217

00:12:41,227 --> 00:12:43,363

SO ULTIMATELY AFTER PUZZLING
OVER THIS FOR A WHILE AND COMING

218

00:12:43,363 --> 00:12:44,797

UP WITH VARIOUS THEORIES AND
EXPLANATIONS AND SO FORTH, THE

219

00:12:44,797 --> 00:12:53,573

CONCLUSION THAT MOST PEOPLE
AGREED ON IS THAT FOR THE WATER,

220

00:12:53,573 --> 00:12:55,975

WE DIDN'T GET THE GLOBAL WATER
ABUNDANCE.

221

00:12:55,975 --> 00:12:57,410

WE WERE MEASURING IN ONE SPOT
AND WE THOUGHT THAT WHEN THE

222

00:12:57,410 --> 00:13:03,249

PROBE WENT IN TO BEYOND 20 BARS,
20 TIMES THE PRESSURE HERE ON

223

00:13:03,249 --> 00:13:05,785

THE EARTH THAT WOULD BE DEEP
ENOUGH TO WHERE THE WATER WAS

224

00:13:05,785 --> 00:13:07,053

WELL MIXED.

225

00:13:07,053 --> 00:13:08,655

BUT WE MUST HAVE BEEN WRONG.

226

00:13:08,655 --> 00:13:13,292

THERE WAS OTHER EVIDENCE FOR
THAT, BUT THE VALUE WAS STILL

227

00:13:13,292 --> 00:13:13,993

CHANGING AS THE PROBE WENT IN.

228

00:13:13,993 --> 00:13:19,532

SO WE GOT UNLUCKY AND IT WENT
INTO THE DRY SPOT.

229

00:13:19,532 --> 00:13:20,633

WENT INTO THE SAHARA DESERT ON
JUPITER.

230

00:13:20,633 --> 00:13:22,235

AND THEREFORE, WE SAW HARDLY ANY
WATER, BUT THAT DOESN'T

231

00:13:22,235 --> 00:13:27,940

REPRESENT THE GLOBAL ABUNDANCE
OF WATER ON JUPITER.

232

00:13:27,940 --> 00:13:31,110

WE DON'T KNOW FOR SURE IF THAT'S
TRUE, BUT THAT'S THE EXPLANATION

233

00:13:31,110 --> 00:13:32,612

WE'RE GOING WITH AT THE MOMENT,
BECAUSE OTHERWISE, NOBODY KNOWS

234

00:13:32,612 --> 00:13:40,687

WHY THERE WOULD BE SO LITTLE
WATER.

235

00:13:40,687 --> 00:13:42,055

IT'S AT LEAST A PLAUSIBLE
EXPLANATION, BUT ONE OF THE

236

00:13:42,055 --> 00:13:44,157

REASONS THAT JUNO WANTS TO
MEASURE IT A DIFFERENT WAY.

237

00:13:44,157 --> 00:13:46,893

THEN THE REST OF THESE -- WELL,
THE LEADING THEORY FOR HOW YOU

238

00:13:46,893 --> 00:13:49,862

GET THAT ENRICHMENT, INSTEAD OF
FORMING ALL AT ONCE, FROM THE

239

00:13:49,862 --> 00:13:52,131

SAME CLOUD OF GAS AND DUST THAT
FORMS THE SUN, IMAGINE THAT WHAT

240

00:13:52,131 --> 00:14:02,141

HAPPENED IS ASTEROID SIZED
OBJECTS OUT OFICE, BECAUSE THAT

241

00:14:02,141 --> 00:14:04,243

COULD BE A SOLID, STARTED TO
FORM.

242

00:14:04,243 --> 00:14:10,216

IN THE EARLY SOLAR SYSTEM BEFORE
WE HAD PLANETS THOSE ICY PLANETS

243

00:14:10,216 --> 00:14:14,120

STUCK TOGETHER.

244

00:14:14,120 --> 00:14:15,388

THEY CRASHED INTO EACH OTHER AND

BIG PIECES STUCK.

245

00:14:15,388 --> 00:14:21,027

YOU WOUND UP WITH A PLANET THAT
GREW FIRST FROM ICY PLANET TEZ

246

00:14:21,027 --> 00:14:27,033

MALLS, UNTIL IT HAD ENOUGH GAS
TO GATHER IN THE HYDROGEN AND

247

00:14:27,033 --> 00:14:27,366

HELIUM.

248

00:14:27,366 --> 00:14:31,003

THAT WOULD EXPLAIN THE
ENRICHMENT OF THE HEAVIER

249

00:14:31,003 --> 00:14:31,370

ELEMENTS.

250

00:14:31,370 --> 00:14:34,173

IT WOULD PREDICT THAT YOU FIND A
LOT OF WATER AND HOW IT FORMED.

251

00:14:34,173 --> 00:14:38,644

BECAUSE IF IT FORMED CLOSE TO
THE SUN WHERE IT'S WARM, YOU GET

252

00:14:38,644 --> 00:14:43,316

A DIFFERENT AMOUNT OF WATER THAN
FAR FROM WHERE IT'S COLD.

253

00:14:43,316 --> 00:14:45,284

HOW MUCH IT COULD CARRY DEPENDS
ON THE TEMPERATURE.

254

00:14:45,284 --> 00:14:46,853

THINGS THAT ARE REALLY COLD ARE
GOING TO STICK TO THE WATER BED

255

00:14:46,853 --> 00:14:51,224

OTHER THAN THINGS THAT AREN'
OKAY.

256

00:14:51,224 --> 00:14:55,094

SO IT LEFT US WITH A KEY PUZZLE,
WHAT'S THE WATER AND LEFT US

257

00:14:55,094 --> 00:14:55,561

WITH A MISSION.

258

00:14:55,561 --> 00:15:01,467

WITH A SPACECRAFT ON THE WAY TO
JUPITER TO TRY TO ANSWER THAT

259

00:15:01,467 --> 00:15:04,971

FUNDAMENTAL QUESTION OF HOW DID
JUPITER FORM, WHICH REMEMBER,

260

00:15:04,971 --> 00:15:07,840

IT'S A KEY TO NOT JUST HOW
JUPITER FORMED BUT BECAUSE IT'S

261

00:15:07,840 --> 00:15:13,212

THE LARGEST AND IT FORMED FIRST
IT'S A KEY TO HOW DID THE OTHER

262

00:15:13,212 --> 00:15:14,480

PLANETS FORM, HOW DID SOLAR
SYSTEMS FORM?

263

00:15:14,480 --> 00:15:15,581

WHERE DO WE COME FROM KIND OF
QUESTIONS.

264

00:15:15,581 --> 00:15:19,719

ALL RIGHT.

265

00:15:19,719 --> 00:15:22,321

WELL, I PROMISED TO RUSH THROUGH
AND GET TO WHERE WE COULD ANSWER

266

00:15:22,321 --> 00:15:26,325
QUESTIONS, SO I'LL SPEND EIGHT
HOURS ON THIS SLIDE.

267

00:15:26,325 --> 00:15:33,599
BUT THAT'S BECAUSE IT COVERS
MORE OR LESS THE WHOLE MISSION.

268

00:15:33,599 --> 00:15:36,903
SO WHAT YOU SEE HERE ON THE LEFT
ARE THE FOUR BIG QUESTIONS WE'RE

269

00:15:36,903 --> 00:15:37,403
TRYING TO ANSWER.

270

00:15:37,403 --> 00:15:49,916
OBVIOUSLY, ANY SPACE MISSION,
YOU KNOW, YOU'RE ANSWERING LOTS

271

00:15:49,916 --> 00:15:53,152
OF DIFFERENT QUESTIONS.

272

00:15:53,152 --> 00:15:53,886
BUT THE FIRST THEME IS ORIGINS.

273

00:15:53,886 --> 00:15:55,388
WE WANT TO UNDERSTAND HOW THE
PLANETS FORM, HOW DO SOLAR

274

00:15:55,388 --> 00:15:56,823
SYSTEMS FORM AND THE KEY TO
THAT, THE MOST IMPORTANT SINGLE

275

00:15:56,823 --> 00:15:58,357
NUMBER WE'LL MEASURE PROBABLY IS
THE GLOBAL ABUNDANCE OF WATER.

276

00:15:58,357 --> 00:15:59,392

HOW MUCH WATER IS THERE IN
JUPITER?

277

00:15:59,392 --> 00:16:04,330

NOT FOR THE USUAL REASONS.

278

00:16:04,330 --> 00:16:07,466

YOU HAVE HEARD OF, YOU KNOW,
LOOKING FOR WATER ON MARS OR

279

00:16:07,466 --> 00:16:13,973

LOOKING AT WATER ON EUROPA
BECAUSE WE'RE INTERESTED IN

280

00:16:15,942 --> 00:16:14,273

LIFE.

281

00:16:15,942 --> 00:16:19,045

WHAT WE'RE INTERESTED IN THE
WATER CONTENT FOR IS HOW DID

282

00:16:19,045 --> 00:16:19,679

JUPITER FORM.

283

00:16:19,679 --> 00:16:25,484

WE WANT TO FIND OUT IF THERE'S A
DENSE CORE DOWN IN THERE.

284

00:16:25,484 --> 00:16:26,619

HOW BIG THAT CORE IS, ASSUMING
IT'S THERE.

285

00:16:26,619 --> 00:16:30,756

TELLS YOU ABOUT HOW MANY HEAVY
ELEMENTS CAME IN AND HOW THINGS

286

00:16:30,756 --> 00:16:31,257

WERE PUT TOGETHER.

287

00:16:31,257 --> 00:16:32,058

IT'S ANOTHER CLUE TO THE ORIGIN.

288

00:16:32,058 --> 00:16:34,527

IN GENERAL WE WANT TO UNDERSTAND
THE INTERIOR OF JUPITER.

289

00:16:34,527 --> 00:16:39,498

LOOK AT JUPITER, WE'RE SEEING
THIS ENORMOUS ATMOSPHERE.

290

00:16:39,498 --> 00:16:59,986

300 TIMES THE MASS OF THE EARTH,
YOU CAN FIT OVER A THOUSAND

291

00:16:59,986 --> 00:17:00,486

EARTHS INSIDE IT.

292

00:17:00,486 --> 00:17:01,988

WHAT WE SEEING IS THE TOPS --
WE'RE SEEING IS THE TOPS OF THE

293

00:17:01,988 --> 00:17:03,022

CLOUDS FLOATING IN THE
ATMOSPHERE.

294

00:17:03,022 --> 00:17:04,223

A TINY THIN LAYER OF JUPITER WE
WANT TO SEE.

295

00:17:04,223 --> 00:17:05,524

WE WANT TO FIND OUT WHAT'S
INSIDE THERE, WHAT'S THE

296

00:17:05,524 --> 00:17:06,092

INTERIOR MADE OUT OF.

297

00:17:06,092 --> 00:17:07,493

SO WE'LL DO THAT BY MEASURING
GRAVITY FROM JUPITER AND THE

298

00:17:07,493 --> 00:17:08,160

MAGNETIC FIELD FROM JUPITER.

299

00:17:08,160 --> 00:17:09,629

WE'LL LOOK AT THE WATER BY
MEASURING BOTH OF THOSE ANDÑi T

300

00:17:09,629 --> 00:17:11,931

RADIO WAVES THAT COME OUT OF
JUPITER.

301

00:17:11,931 --> 00:17:16,702

SO I'VE GOT COLOR CODING OVER
L TSEILAFCTANOFSEE IT.

302

00:17:16,702 --> 00:17:23,743

THE QUESTIONS, BUT PRIMARILY IF
YOU WANT TO KNOW ABOUT THE

303

00:17:23,743 --> 00:17:28,080

ERERANWHH STMENTS INOOFOTHGRN TS
WILL MEASURE THAT AND THE BLUE

304

00:17:28,080 --> 00:17:29,982

FOR THE INTERIOR AND SO FORTH.

305

00:17:29,982 --> 00:17:34,553

WE WANT TO UNDERSTAND THE
ATMOSPHERE OF THE PLANETS,

306

00:17:34,553 --> 00:17:35,655

MSOLY ATMOSPHERE FROM WHAT WE
CAN SEE.

307

00:17:35,655 --> 00:17:37,189

WE WANT TO UNDERSTAND ABOUT THE
ATMOSPHERIC COMPOSITION AND WE

308

00:17:37,189 --> 00:17:46,566

WE EPLLHO TNGGOTAND THE DYNAMICS,
WE SEE THE GREAT RED SPOT IS A

309

00:17:46,566 --> 00:17:51,470

STORM BIGGER THAN THE ENTIRE
EAH.

310

00:17:51,470 --> 00:17:52,471

WE HAVE AN IDEA WHAT POWERS
THAT.

311

00:17:52,471 --> 00:18:00,346

IT'SOWEDY E ATEANG
OUT FROM INSIDE JUPITER.

312

00:18:00,346 --> 00:18:01,380

WE WANT TO KNOW HOW DEEP DOES
THAT GO.

313

00:18:01,380 --> 00:18:02,915

WE SEE THE BELTS AND ZONES, JET
STREAMS MOVING AT HUNDREDS OF

314

00:18:02,915 --> 00:18:04,016

MILES AN HOUR IN DIFFERENT
DIRECTIONS.

315

00:18:04,016 --> 00:18:04,517

WHAT DRIVES THAT?

316

00:18:04,517 --> 00:18:06,218

HOW DOES THAT BECOME THE JUPITER
THAT WE SEE?

317

00:18:06,218 --> 00:18:15,127

ALL OF THAT IS TIED UP IN THIS
QUESTION OF THE ATMOSPHERE, THE

318

00:18:15,127 --> 00:18:15,494
DYNAMICS.

319

00:18:15,494 --> 00:18:21,033
AND THEN FINALLY, JUPITER HAS
THIS HUGE MAGNETIC FIELD AN IT

320

00:18:21,033 --> 00:18:27,073
HAS A MAGNETOSPHERE THAT
STRETCHES SO BIG, IF IT WAS

321

00:18:27,073 --> 00:18:28,708
VISIBLE FROM THE EARTH IT WOULD
BE BIGGER THAN THE FULL MOON.

322

00:18:28,708 --> 00:18:31,243
ENORMOUS MAGNETIC FIELD AROUND
JUPITER TRAPS PARTICLES.

323

00:18:31,243 --> 00:18:32,211
IT HAS A RAPIDLY ROTATING
PLANET.

324

00:18:32,211 --> 00:18:39,819
JUPITER, 300 TIMES THE MASS OF
THE EARTH.

325

00:18:39,819 --> 00:18:42,388
MORE THAN A THOUSAND TIMES THE I
VOLUME.

326

00:18:42,388 --> 00:18:46,325
IT SPINS TWICEçó AS FAST AS THE
EARTH.

327

00:18:46,325 --> 00:18:48,894
WELL, THAT MAGNETOSPHERE IS A
MAGNETIC FIELD SPINNING AROUND,

328

00:18:48,894 --> 00:18:52,665
IT HAS TO TIE UP WITH THE
MAGNETIC FIELD FROM THE SUN.

329
00:18:52,665 --> 00:18:56,068
SO IF YOU GET FAR FROM JUPITER,
IT'S GOT TO MATCH UP TO A

330
00:18:56,068 --> 00:19:00,673
MAGNETIC FIELD THAT'S NOT
ROTATING.

331
00:19:00,673 --> 00:19:04,010
CLOSER TO THE PLANET IT'S
ROTATING LIKE CRAZY.

332
00:19:04,010 --> 00:19:09,782
SOMEWHERE IN BETWEEN, THE CLUTCH
HAS TO SLIP, RIGHT?

333
00:19:09,782 --> 00:19:10,950
WE THINK THAT'S WHAT DRIVES THE
AURORA.

334
00:19:10,950 --> 00:19:17,256
SO YOU SEE THESE NORTHERN AND
SOUTHERN LIGHTS STREAMING DOWN

335
00:19:17,256 --> 00:19:21,661
THE MAGNETIC LINES, CRUSHING IN
THE UPPER ATMOSPHERE AND GLOWING

336
00:19:21,661 --> 00:19:23,996
THAT'S THE NORTHERN OR THE
SOUTHERN LIGHTS.

337
00:19:23,996 --> 00:19:26,632
WE WANT TO UNDERSTAND THE
MECHANISM THAT MAKES THAT WORK.

338

00:19:26,632 --> 00:19:27,900
HOW DOES THIS WHOLE
MAGNETOSPHERE WORK, SO THAT'S

339
00:19:27,900 --> 00:19:33,673
ANOTHER CENTRAL AREA OF WHAT
WE'RE TRYING TO STUDY.

340
00:19:33,673 --> 00:19:35,174
NOW, IF IT TURNS OUT WE'RE IN A
PRETTY GOOD ORBIT TO DO THAT, I

341
00:19:35,174 --> 00:19:42,314
GUESS THERE'S AN ORBIT DRAWN ON
HERE, BUT YOU CAN'T SEE IT.

342
00:19:42,314 --> 00:19:43,783
CAN YOU SEE IT IN THE AUDIENCE,
CAN YOU SEE THE LINE DRAWN IN

343
00:19:43,783 --> 00:19:46,385
THERE?

344
00:19:46,385 --> 00:19:47,420
IT'S A THIN LINE.

345
00:19:47,420 --> 00:19:48,888
BUT BASICALLY, OUR PLAN IS THE
SPACECRAFT IS GOING TO COME IN

346
00:19:48,888 --> 00:19:53,526
OVER THE POLE OF JUPITER AND
AROUND LIKE THAT.

347
00:19:53,526 --> 00:20:00,232
A COUPLE HOURS FROM POLE TO POLE
AND THENxD 14 DAYS OUT FAR FROM

348
00:20:00,232 --> 00:20:01,767
THE PLANET AND THEN COME AROUND

AGAIN EVERY TWO WEEKS FOR ABOUT

349

00:20:01,767 --> 00:20:02,268

A YEAR AND A HALF.

350

00:20:02,268 --> 00:20:09,775

AND ONE OF THE REASONS WE'RE
DOING THAT IS JUPITER IS

351

00:20:09,775 --> 00:20:11,777

SURROUND BY RADIATION BELTS.

352

00:20:11,777 --> 00:20:15,981

THAT MAGNETIC FIELD IS TRAPPING
HIGH ENERGY PARTICLES, HIGH

353

00:20:15,981 --> 00:20:20,786

ENERGY ELECTRONS CIRCLING.

354

00:20:20,786 --> 00:20:21,787

LIKE THE VAN ALLEN BELTS ON
EARTH.

355

00:20:21,787 --> 00:20:30,563

JUPITER IS MUCH BIGGER AND THOSE
HIGH ENERGY ELECTRONS ARE GOING

356

00:20:30,563 --> 00:20:32,064

TO FLY THE ELECTRONICS OF THE
SPACECRAFT IF YOU FLY THROUGH

357

00:20:32,064 --> 00:20:32,331

THEM.

358

00:20:32,331 --> 00:20:33,599

WE NEED A WAY TO AVOID THE
BELTS.

359

00:20:33,599 --> 00:20:41,340

PREVIOUS SPACECRAFT HAVE DONE
THE SENSIBLE THING, THEY HAVE

360

00:20:41,340 --> 00:20:47,580

STAYED OUT THE RADIATION BELT,
FAR FROM THE PLANET.

361

00:20:47,580 --> 00:20:48,247

WE'RE EITHER BRAVER OR DUMBER.

362

00:20:48,247 --> 00:20:49,715

WHAT WE'RE DOING WITH OUR
SPACECRAFT WE'LL FLY IT UNDER

363

00:20:49,715 --> 00:20:50,616

THE RADIATION BELT.

364

00:20:50,616 --> 00:20:52,551

BETWEEN THAT DOUGHNUT AND THE
PLANET.

365

00:20:52,551 --> 00:20:55,855

SO WE COME IN OVER THE POLE OF
JUPITER.

366

00:20:55,855 --> 00:20:58,224

IF YOU CAN'T SEE THE LINE, I'LL
DRAW IT WITH THE ARROW.

367

00:20:58,224 --> 00:21:02,128

COME OVER THE POLE OF JUPITER,
DUCK DOWN IN HERE AND THREAD THE

368

00:21:02,128 --> 00:21:04,930

NEEDLE BETWEEN THE RADIATION
BELT AND THE PLANET AND COME OUT

369

00:21:04,930 --> 00:21:05,231

AGAIN.

370

00:21:05,231 --> 00:21:11,303

SO OUR FIRST ORBIT IS COMING IN
PRETTY MUCH PARALLEL LIKE THAT.

371

00:21:11,303 --> 00:21:15,040

SO WE'VE GOT A NICE PATH OVER
THE POLE, GET A GREAT VIEW OF

372

00:21:15,040 --> 00:21:16,575

THE POLES OF JUPITER.

373

00:21:16,575 --> 00:21:17,543

WHICH HAVEN'T BEEN SEEN WELL.

374

00:21:17,543 --> 00:21:20,379

COME IN CLOSE TO THE PLANET SO
WE CAN MEASURE THE GRAVITY OF

375

00:21:20,379 --> 00:21:22,848

THE MAGNETIC FIELD AND ZIP OUT
THE OTHER SIDE.

376

00:21:22,848 --> 00:21:28,320

SPEND TWO WEEKS RECOVERING AND
DO IT ALL AGAIN.

377

00:21:28,320 --> 00:21:32,158

BUT THE PROBLEM IS JUPITER IS
NOT A PERFECT SPHERE.

378

00:21:32,158 --> 00:21:35,094

REMEMBER IT'S ROTATING EVERY TEN
HOURS SO IT STRETCHES OUT THE

379

00:21:35,094 --> 00:21:38,397

EQUATOR AND THAT MEANS OUR ORBIT
AROUND JUPITER WON'T STAY THAT

380

00:21:38,397 --> 00:21:38,697

WAY.

381

00:21:38,697 --> 00:21:41,200
THE LINE OF THE ORBIT IS GOING
TO SHIFT, SO BY THE END OF THE

382

00:21:41,200 --> 00:21:47,006
MISSION IT'S DOWN LIKE THIS.

383

00:21:47,006 --> 00:21:50,676
PASSING PARTLY THROUGH THE
RADIATION BELTS SO WE'LL BUILD

384

00:21:50,676 --> 00:21:51,744
UP A RADIATION DOSE AS WE GO
ALONG.

385

00:21:51,744 --> 00:21:53,112
THAT'S MOSTLY WHAT DETERMINES
THE LIFETIME OF THE MISSION.

386

00:21:53,112 --> 00:21:54,780
ALL RIGHT.

387

00:21:54,780 --> 00:21:56,348
I TOLD YOU IT WOULD TAKE A LONG
TIME ON THIS SLIDE.

388

00:21:56,348 --> 00:22:08,327
SOñr WE'RE GOING THE MEASURE TH
INTERIOR OF JUPITER.

389

00:22:08,327 --> 00:22:13,566
GRAVITY COS FROM THE ENTIRE
PLANET, INCLUDING THE BELTS AND

390

00:22:13,566 --> 00:22:16,802
OF THE SPACECRAFT AS IT FALLS
AROUND THE PLANE WE'LL BEçó

391

00:22:16,802 --> 00:22:19,305

MEASURING THE GRAVITY FROM
JUPITER AND MEASURING THE

392

00:22:19,305 --> 00:22:19,705

INTERIOR.

393

00:22:19,705 --> 00:22:25,477

SECOND, REMEMBER THE MAGNETIC
FIELD I SAID COMES FROM THE

394

00:22:25,477 --> 00:22:27,813

OCEAN OF LIQUID METALLIC
HYDROGEN DEEP INSIDE THE PLANET.

395

00:22:27,813 --> 00:22:32,218

WE'RE MEASURING THE METALLIC
LIQUID HYDROGEN.

396

00:22:32,218 --> 00:22:34,653

THEN MICROWAVES PENETRATE
THROUGH THE CLOUDS, SO WE HAVE

397

00:22:34,653 --> 00:22:35,855

MICROWAVE RECEIVER ON BOARD
THATR!HTáJjURUáQ

398

00:22:35,855 --> 00:22:43,195

THATR!HTHE NATURAL
RADIO EMISSION ON JUPITER, WE'LL

399

00:22:43,195 --> 00:22:44,864

SEE THAT RADIO GLOW COMING FROM
THE INSIDE AND WE USE THAT TO

400

00:22:44,864 --> 00:22:51,036

LEARN ABOUT THE DEEP ATMOSPHERE.

401

00:22:51,036 --> 00:22:54,740

THEN AS Iñr MENTIONED WE HAVE TS
INTEREST IN THE MAGNETOSPHERE WE

402

00:22:54,740 --> 00:22:55,941

HAVE A WHOLE SUITE OF
INSTRUMENTS ON BOARD THE

403

00:22:55,941 --> 00:22:56,375

SPACECRAFT.

404

00:22:56,375 --> 00:23:02,748

WHOSE JOB IT IS TO MEASURE THE
PARTICLES THAT HIT THE

405

00:23:02,748 --> 00:23:03,148

SPACECRAFT.

406

00:23:03,148 --> 00:23:13,092

MEASURE THE PLASMA WAVES AND THE
PLASMA IN THE MAGNETOSPHERE AND

407

00:23:13,092 --> 00:23:15,761

ULTRAVIOLET SPECTROMETER THAT
WILL TAKE PICTURES OF THE AURORA

408

00:23:15,761 --> 00:23:19,498

AND MEASURE THE SPECTRA THAT
WILL HELP US WITH THEñi

409

00:23:19,498 --> 00:23:19,898

ATMOSPHERE.

410

00:23:19,898 --> 00:23:22,034

THEN WE HAVE A VISIBLE CAMERA ON
BOARD.

411

00:23:22,034 --> 00:23:23,769

WHICH ACTUALLY IT WILL DO SOME
GOOD SCIENCE, BUT IT'S NOT THERE

412
00:23:23,769 --> 00:23:24,169
FOR SCIENCE.

413
00:23:24,169 --> 00:23:27,306
IT'S AN OUTREACH CAMERA.

414
00:23:27,306 --> 00:23:29,575
THE REASON WE'RE CARRYING A
CAMERA IS MOSTLY FOR OUTREACH

415
00:23:29,575 --> 00:23:35,547
AND EDUCATION SO THAT THE
GENERAL PUBLIC CAN HAVE A HAND

416
00:23:35,547 --> 00:23:36,115
IN USING THAT CAMERA.

417
00:23:36,115 --> 00:23:39,451
I'LL TALK ABOUT THAT AT THE END
OF THE TALK.

418
00:23:39,451 --> 00:23:39,852
ALL RIGHT.

419
00:23:39,852 --> 00:23:47,192
SO FINALLY, OFF OF THIS SLIDE.
BUT THERE'S THE SPAFT CRAFT WITH

420
00:23:47,192 --> 00:23:48,193
THE DIFFERENT INSTRUMENTS ON IT.

421
00:23:48,193 --> 00:23:49,194
TO SHOW YOU ROUGHLY WHERE THEY
ARE.

422
00:23:49,194 --> 00:23:52,231
THE GRE BIG THINGS ARE THE
SOLAR PANELS TO GIVE YOU A SEE

423

00:23:52,231 --> 00:23:52,598

OF SCALE.

424

00:23:52,598 --> 00:23:53,599

LOTS OF DIFFERENT WAYS TO DO
THAT.

425

00:23:53,599 --> 00:24:02,908

BUT THE WAY I LIKE TO THINK OF
IT IS IF YOU PART THE 18 -- PARK

426

00:24:02,908 --> 00:24:06,178

THE 18 WHEELER TRUCK ON THE
SPACECRAFT, FIRST OF ALL, I'D

427

00:24:06,178 --> 00:24:07,346

KILL YOU IF YOU PARKED IT ON THE
SPACECRAFT.

428

00:24:07,346 --> 00:24:10,649

BUT THEN THE SIZE OF THE
CONTAINER PART OF THE TRUCK,

429

00:24:10,649 --> 00:24:16,722

JUST ABOUT FIT ON ONE OF THOSEÑ
SOLAR RAYS.

430

00:24:16,722 --> 00:24:17,856

ON ONE OF THOSE ARMS.

431

00:24:17,856 --> 00:24:19,024

THAT'S THE SIZE OF IT.

432

00:24:19,024 --> 00:24:23,028

ANOTHER WAY TO LOOK AT IT ISçó
A PROFESSIONAL BASKETBALL COURT,

433

00:24:23,028 --> 00:24:24,296

YOU COULD BARELY FIT THE

SPACECRAFT ON THE COURT.

434

00:24:24,296 --> 00:24:24,763

THAT'S THE SIZE.

435

00:24:24,763 --> 00:24:32,404

THEN THERE'S A MAGNETOMETER ON
THE BOOM ON THE FAR END OF THE

436

00:24:32,404 --> 00:24:32,805

SPACECRAFT.

437

00:24:32,805 --> 00:24:38,911

ANY IDEA WHY I HAVE THE
MAGNETOMETER WAY OUT ON THE ENDi

438

00:24:38,911 --> 00:24:40,879

TO BE AWARE FROM THE SPACECRAFT,
RIGHT.

439

00:24:40,879 --> 00:24:44,350

I WANT TO MEASURE THE MAGTIC
FIELD OF JUPITER, NOT THE

440

00:24:44,350 --> 00:24:46,719

MAGNETIC FIELD OF THE
SPACECRAFT.

441

00:24:46,719 --> 00:24:55,627

BY HAVING THE MAGNETOMETER FAR
FROM THE SPACECRAFT AND HAVING

442

00:24:55,627 --> 00:25:01,300

ONE CLOSER, TO DO A COMPARISON,
AND HAVING A MAGNETICALLY CLEAN

443

00:25:01,300 --> 00:25:05,270

SPACECRAFT, KEEP IT AS LOW AS WE
CAN MAKE IT, PUT ALL OF THOSE

444

00:25:05,270 --> 00:25:09,475

TOGETHER AND JACK McINNERRY CAN
MEASURE THE MAGNETIC FIELD OF

445

00:25:09,475 --> 00:25:14,880

JUPITER AND NOT SO MUCH THE
MAGNETIC FIELD OF THE

446

00:25:14,880 --> 00:25:15,280

SPACECRAFT.

447

00:25:15,280 --> 00:25:17,716

ALTHOUGH THE TRUTH IS HE CAN
MEASURE THE SPACECRAFT REALLY

448

00:25:17,716 --> 00:25:21,487

WELL TOO.

449

00:25:21,487 --> 00:25:21,787

OKAY.

450

00:25:21,787 --> 00:25:23,789

SIX DIFFERENT CHANNELS ARE
SPREAD OUT AROUND IT.

451

00:25:23,789 --> 00:25:30,329

WE'LL DO THE GRAVITY SCIENCE,
I'LL TALK ABOUT THAT IN A WHILE.

452

00:25:30,329 --> 00:25:31,330

YOU CAN SEE THE OTHER
INSTRUMENTS.

453

00:25:31,330 --> 00:25:32,765

I WON'T GO THROUGH ONE BY ONE
BECAUSE THEY'RE LINES ON THE

454

00:25:32,765 --> 00:25:33,332

CHART AT THE MOMENT.

455

00:25:33,332 --> 00:25:34,800

SO INSTEAD LET'S TALK ABOUT THE
MAIN EXPERIMENTS A LITTLE BIT.

456

00:25:34,800 --> 00:25:41,974

SO THE FIRST ONE THAT WE'LL TALK
ABOUT IS THE MICROWAVE

457

00:25:41,974 --> 00:25:42,574

RADIOMETER CALLED MWR.

458

00:25:42,574 --> 00:25:50,816

WHAT WE HAVE IS SIX MICROWAVE
ANTENNAS DISTRIBUTED AROUND THE

459

00:25:50,816 --> 00:25:51,216

SPACECRAFT.

460

00:25:51,216 --> 00:25:53,218

THE LOWEST FREQUENCY, THIS GREAT
BIG SHINING THING HERE, THIS

461

00:25:53,218 --> 00:26:00,959

ANTENNA PRETTY MUCH DETERMINED
THE SIZE OF THE SPACECRAFT.

462

00:26:00,959 --> 00:26:02,828

WHEN WE WERE FIGURING O HOW
BIG IT NEEDS TO BE, BASICALLY,

463

00:26:02,828 --> 00:26:05,731

THE ANSWER WAS SO THAT ONE SIDE
IS BIG ENOUGH TO PUT THIS ON IT.

464

00:26:05,731 --> 00:26:06,565

BUT THAT'S FIVE OTHER CHANNELS.

465

00:26:06,565 --> 00:26:19,778

SO THAT'S THE LARGEST CHANNEL A6
600 MEGAHERTZ AND THEN ANOTHER

466

00:26:19,778 --> 00:26:29,988

CHANNEL AT TWICE THAT FREQUENCY
AND A PANEL ON THE THREE THROUGH

467

00:26:29,988 --> 00:26:30,456

FIVE CHANNELS.

468

00:26:30,456 --> 00:26:32,090

SO THEY FIT ON THE SAME PANEL
AND A TINY LITTLE HORN FOR THE

469

00:26:32,090 --> 00:26:37,563

HIGH FREQUENCY PANEL.

470

00:26:37,563 --> 00:26:38,997

THE WAY THEY WORK ON THE TWO
SIDES THEY LOOK OUT AWAY FROM

471

00:26:38,997 --> 00:26:42,868

THE SPACECRAFT AND THE
SPACECRAFT SPINS THIS WAY LIKE A

472

00:26:42,868 --> 00:26:43,135

TOP.

473

00:26:43,135 --> 00:26:44,603

SO EACH CHANNEL GETS A TURN TO
SWEEP ACROSS THE SKY AND SWEEP

474

00:26:44,603 --> 00:26:45,070

ACROSS JUPITER.

475

00:26:45,070 --> 00:26:49,608

FURTHERMORE, YOU PUT THE
SPACECRAFT UP HERE IN OUR ORBIT,

476

00:26:49,608 --> 00:26:51,677
AND YOU THINK ABOUT WHAT
HAPPENS, IF I PICK A SPOT ON

477
00:26:51,677 --> 00:26:57,549
JUPITER I'M GOING TO LOOK AT
THAT SPOT FROM RIGHT ABOVE, BUT

478
00:26:57,549 --> 00:27:02,754
I'M ALSO GOING TO LOOK AT IT
LATER IN THE TRAJECTORY FROM A

479
00:27:02,754 --> 00:27:08,260
DIFFERENT ANGLE, AND EARLIER I
LOOKED AT IT FROM THE SHALLOWER

480
00:27:08,260 --> 00:27:08,594
ANGLE.

481
00:27:08,594 --> 00:27:13,565
I GET TO LOOK AT FROM A RANGE OF
ANGLES AT SIX DIFFERENT

482
00:27:13,565 --> 00:27:14,233
CHANNELS.

483
00:27:14,233 --> 00:27:19,238
THAT'S HELPFUL BECAUSE NOT ONLY
AM I DOING A C.A.T. SCAN, BY

484
00:27:19,238 --> 00:27:20,706
LOOKING AT THE DIFFERENT ANGLES
BUT EACH OF THE SIX DIFFERENT

485
00:27:20,706 --> 00:27:22,708
CHANNELS PENETRATES A DIFFERENT
DEPTH INTO THE ATMOSPHERE.

486
00:27:22,708 --> 00:27:24,142
ONE OF THE MAIN COMPONENTS THAT

DETERMINES HOW DEEP IT

487

00:27:24,142 --> 00:27:26,311

PENETRATES IS WATER.

488

00:27:26,311 --> 00:27:32,417

SO BY MEASURING HOW DEEP THEY GO
INTO THE ATMOSPHERE WE'RE

489

00:27:32,417 --> 00:27:36,522

EFFECTIVELY MEASURING HOW MUCH
WATER THERE IS.

490

00:27:36,522 --> 00:27:38,423

NOW REMEMBER I MENTIONED EARLY
THAT WE HAD A TEMPERATURE

491

00:27:38,423 --> 00:27:38,957

PROFILE ON JUPITER.

492

00:27:38,957 --> 00:27:42,761

WE KNOW SOMETHING ABOUT THE
TEMPERATURE PROFILE.

493

00:27:42,761 --> 00:27:44,730

WELL, THE WAY THE TEMPERATURE
VARIES DEPENDS ON HOW MUCH WATER

494

00:27:44,730 --> 00:27:49,134

IS IN THE ATMOSPHERE AND OTHER
THINGS.

495

00:27:49,134 --> 00:27:53,272

SO BY MEASURING THE RADIO WAVES
WHICH ARE COMING FROM THE GLOW,

496

00:27:53,272 --> 00:27:57,142

SO HOW HOT IT IS TELLS YOU HOW
MUCH RADIO POWER YOU'LL GET OUT,

497

00:27:57,142 --> 00:28:00,846

BY MEASURING WHAT WE SEE IN EACH
OF THE SIX DIFFERENT CHANNELS A

498

00:28:00,846 --> 00:28:04,483

WHOLE RANGE OF ANGLES, PUTTING
THAT TOGETHER WITH THE MODEL OF

499

00:28:04,483 --> 00:28:07,152

THE ATMOSPHERE AND HOW THE
TEMPERATURE SHOULD VARY

500

00:28:07,152 --> 00:28:10,222

DEPENDING ON HOW MUCH WATER
THERE IS, WE CAN TEASE OUT HOW

501

00:28:10,222 --> 00:28:13,825

MUCH AMMONIA AND HOW MUCH WATER
AND OTHER ELEMENTS THERE ARE IN

502

00:28:13,825 --> 00:28:16,795

THE ATMOSPHERE OF JUPITER TO
PULL OUT THE PRIZE, WHICH IS THE

503

00:28:16,795 --> 00:28:21,466

GLOBAL WATER ABUNDANCE OF THE
PLANET.

504

00:28:21,466 --> 00:28:23,268

NOW, WE GET DOWN WITH OUR
LONGEST WAVE LENGTH, OUR LOWEST

505

00:28:23,268 --> 00:28:29,975

FREQUENCY CHANNEL PENETRATES
DOWN TO SOME OF THE INFORMATION

506

00:28:29,975 --> 00:28:33,579

THAT'S IT'S GETTING COMING FROM
A THOUSAND BARS.

507

00:28:33,579 --> 00:28:35,080

IT SOUNDS REALLY GREAT.

508

00:28:35,080 --> 00:28:40,452

BUT ON THE SCALE OF JUPITER,
THAT'S PRETTY SMALL.

509

00:28:40,452 --> 00:28:43,655

NONETHELESS, WE THINK IT'S WAY
BENEATH THE WEATHER LAYER.

510

00:28:43,655 --> 00:28:47,659

BENEATH ALL THE STORMS AND STUFF
THAT WE SEE AND DOWN TO A LAYER

511

00:28:47,659 --> 00:28:49,161

WHERE THE WATER SHOULD BE WELL
MIXED.

512

00:28:49,161 --> 00:28:50,395

SO WE'LL BE MEASURING THE GLOBAL
WATER ABUNDANCE.

513

00:28:50,395 --> 00:28:55,934

OF COURSE, JUST IN CASE WE'RE
WRONG ABOUT THAT, WE'LL FIND OUT

514

00:28:55,934 --> 00:28:59,037

BECAUSE UNLIKE DROPPING A PROBE
INTO ONE SPOT WE'LL LOOK AT A

515

00:28:59,037 --> 00:29:00,606

WIDE RANGE OF JUPITER.

516

00:29:00,606 --> 00:29:07,112

WE'LL BE LOOKING AT LOTS OF
DIFFERENT PLACES SO WE'LL KNO

517

00:29:07,112 --> 00:29:08,547

IF WE'RE NOT GETTING THE SAME
WATER NUMBER IN THE SAME PLACES

518

00:29:08,547 --> 00:29:10,115
THAT WE'RE NOT FEEDING DEEP
ENOUGH OR WE NEED TO UNDERSTAND

519

00:29:10,115 --> 00:29:10,649
THE PICTURE BETTER.

520

00:29:10,649 --> 00:29:10,949
OKAY.

521

00:29:10,949 --> 00:29:15,287
REASON YOU CAN'T DO THAT FROM
THE EARTHS TO -- IF YOU HAD

522

00:29:15,287 --> 00:29:20,392
RADIOIZED, THIS IS WHAT JUPITER
WOULD LOOK LIKE FROM THE EARTH.

523

00:29:20,392 --> 00:29:23,629
THOSE RADIATION BELTS I
MENTIONED BEFORE WITH THE HIGH

524

00:29:23,629 --> 00:29:27,165
ENERGY ELECTRONS, TAKE ELECTRONS
AND YOU WHIZ THEM iR%UND IN THE

525

00:29:27,165 --> 00:29:28,600
MAGNETIC FIELD AND CLOSE TO THE
SPEED OF LIGHT THEY GIVE OFF

526

00:29:28,600 --> 00:29:29,201
RADIO WAVES LIKE CRAZY.

527

00:29:29,201 --> 00:29:35,007
SO FROM THE EARTH, JUPITER GLOWS
IN THE RADIO, BUT IT'S THE HIGH

528

00:29:35,007 --> 00:29:38,110

ENERGY ELECTRONS YOU SEE AND ÇÓ
JUPITER BEHIND IT IS PRETTY DIM

529

00:29:38,110 --> 00:29:38,810

AND HARD TO SEE.

530

00:29:38,810 --> 00:29:50,255

SO YOU CAN'T REALLY DO THIS
MEASUREMENT FROM THE EARTH.

531

00:29:50,255 --> 00:29:51,757

BUT FROM A SPACECRAFT, REMEMBER
I'M PUTTING THE SPACECRAFT RIGHT

532

00:29:51,757 --> 00:29:53,992

THERE UNDERNEATH THE RADIATION
BELT.

533

00:29:53,992 --> 00:29:55,994

PLANET AND THE BRIGHT LIGHT FROM
THE RADIATION BELTS IS SHINING

534

00:29:55,994 --> 00:29:58,263

OVER OUR SHOULDER INSTEAD OF IN
OUR EYES.

535

00:29:58,263 --> 00:30:00,599

WE STILL HAVE TO ACCOUNT FOR IT.

536

00:30:00,599 --> 00:30:01,600

WE SUBTRACT OUT ITS
CONTRIBUTION.

537

00:30:01,600 --> 00:30:03,068

BECAUSE SOME OF IT'S GOING TO
LEAK IN BUT THAT'S NOT AS BIG A

538

00:30:03,068 --> 00:30:09,975

PROBLEM SINCE THE SPACECRAFT IS
SPINNING AND ALL OF THOSEÑi SIX

539

00:30:09,975 --> 00:30:13,879

CHANNELS THAT WE'RE LOOKING AT
THE PLANET, EVERY 30 SECONDS ARE

540

00:30:13,879 --> 00:30:15,847

LOOKING OUT THE RADIATION
BELT.

541

00:30:15,847 --> 00:30:19,584

SO WE KNOW -- WE MEASURE WHAT WE
WANT TO SUBTRACT AND MEASURE THE

542

00:30:19,584 --> 00:30:21,953

PLANET AND SPIN AROUND AND WE
MEASURE WHAT WE WANT TO SUBTRACT

543

00:30:21,953 --> 00:30:23,088

AND MEASURE THE PLANET.

544

00:30:23,088 --> 00:30:23,555

ALL RIGHT.

545

00:30:23,555 --> 00:30:26,158

SO THAT'S THE BIG PICTURE VIEW
OF THE MICROWAVE RADIOMETER.

546

00:30:26,158 --> 00:30:27,759

SEE, WE'RE SPEEDING UP A LITTLE
BIT.

547

00:30:27,759 --> 00:30:29,995

THEN THE GRAVITY MEASUREMENT.

548

00:30:29,995 --> 00:30:34,266

GRAVITY IS THE LARGEST
INSTRUMENT THAT'S PART OF

549

00:30:34,266 --> 00:30:34,700

MISSION JUNO.

550

00:30:34,700 --> 00:30:43,408

AND THE REASON I SAY THAT IS THE GRAVITY INSTRUMENT ISN'T ON THE

551

00:30:45,677 --> 00:30:43,809

SPACECRAFT.

552

00:30:45,677 --> 00:30:48,647

IT'S THE LINK BETWEEN THE COMMUNICATIONS ANTENNAS ON THE

553

00:30:48,647 --> 00:30:50,082

SPACECRAFT AND THE GIANT RADIO TELESCOPES HERE ON THE EARTH

554

00:30:50,082 --> 00:30:54,419

THAT MAKE THE GRAVITY INSTRUMENT.

555

00:30:54,419 --> 00:30:55,821

IN EFFECT IT'S AN INSTRUMENT THAT STRETCHES FROM THE EARTH

556

00:30:55,821 --> 00:30:56,421

ALL THE WAY TO JUPITER.

557

00:30:56,421 --> 00:31:02,728

AND THE WAY THAT WORKS IS, IF YOU SEND A RADIO SIGNAL FROM

558

00:31:02,728 --> 00:31:05,564

HERE UP TO THE SPACECRAFT AND THE SPACECRAFT TURNS AROUND AND

559

00:31:05,564 --> 00:31:07,065

SENDS IT RIGHT BACK AT THE SAME

FREQUENCY, THE FACT THAT THE

560

00:31:07,065 --> 00:31:11,903

SPACECRAFT IS MOVING IS GOING TO
SHIFT THE FREQUENCY OF THAT

561

00:31:11,903 --> 00:31:12,337

RADIO SIGNAL.

562

00:31:12,337 --> 00:31:17,709

AND IT GIVES YOU A VERY PRECISE
MEASUREMENT OF EXACTLY HOW FAST

563

00:31:17,709 --> 00:31:19,144

THE SPACECRAFT IS MOVING IN THE
DIRECTION AWAY FROM YOU, OR

564

00:31:19,144 --> 00:31:21,913

TOWARDS YOU.Ñi
THAT'S CALLED THE DOPPLER EFFECT

565

00:31:21,913 --> 00:31:27,185

AND YOU HEAR THE SAME THING
EVERY TIME YOU HEAR POLICE CAR

566

00:31:27,185 --> 00:31:28,353

OR AN AMBULANCE WITH ITS SIREN
ON DRIVE BY.

567

00:31:28,353 --> 00:31:38,864

WHEN THE SOUND SOUNDS DIFFERENT
AS IT'S COMING DIFFERENT TOWARDS

568

00:31:38,864 --> 00:31:40,832

YOU AS AWAY FROM YOU AND THAT'S
BECAUSE THE SOUND WAVES ARE

569

00:31:40,832 --> 00:31:46,238

GETTING SHIFTED AS IT COMES
TOWARD YOU AND THEN SHIFTED THE

570

00:31:46,238 --> 00:31:46,705

OTHER WAY AWAY.

571

00:31:46,705 --> 00:31:49,808

WE USE THAT ON THE SPACECRAFT TO
MEASURE JUNO'S SPEED AS IT FALLS

572

00:31:49,808 --> 00:31:50,575

PAST JUPITER.

573

00:31:50,575 --> 00:31:53,478

WE DO THAT WITH A COUPLE OF
RADIO INSTRUMENTS ON THE

574

00:31:53,478 --> 00:31:55,380

SPACECRAFT THAT SEND A SIGNAL
BACK.

575

00:31:55,380 --> 00:32:03,121

WE HAVE A MAIN COMMUNICATION
ANTENNA AND THE EXBAND RECEIVER

576

00:32:03,121 --> 00:32:04,589

AT EIGHT GIGAHERTZ THAT WE USE
TO COMMUNICATE, WE CAN MEASURE

577

00:32:04,589 --> 00:32:06,558

THE DOPPLER FROM THAT.

578

00:32:06,558 --> 00:32:08,193

MEASURE THE SPEED.

579

00:32:08,193 --> 00:32:12,631

WE HAVE A KA BAND TRANSRECEIVER
THAT TAKES THAT SIGNAL AND

580

00:32:12,631 --> 00:32:13,532

BOUNCES IT BACK TO THE.

581

00:32:13,532 --> 00:32:17,769

THAT WAS BUILT IN ITALY AND
CONTRIBUTED BY THE ITALY SPACE

582

00:32:17,769 --> 00:32:20,872

AGENCY, BECAUSE THE HIGHER
FREQUENCY PENETRATES THROUGH THE

583

00:32:20,872 --> 00:32:26,044

SOLAR SYSTEM BETTER AND DOESN'T
GET DISTORTED THE SAME WAY.

584

00:32:26,044 --> 00:32:26,344

OKAY.

585

00:32:26,344 --> 00:32:28,814

SO IMAGINE THE SPACECRAFT NOW
FALLING PAST THE PLANET.

586

00:32:28,814 --> 00:32:35,253

IF THAT'S A CORE IN THERE AND
THE THING IS SPINNING AROUND

587

00:32:35,253 --> 00:32:36,721

EVERY TEN HOURS, THE CORE WILL
STRETCH DIFFERENTLY THAN THE

588

00:32:36,721 --> 00:32:41,326

REST OF THE PLANET.

589

00:32:41,326 --> 00:32:42,561

SO IT GOES BY AND SPEEDS UP AND
SLOWS DOWN AGAIN.

590

00:32:42,561 --> 00:32:47,399

HOW MUCH IT SPEEDS UP AND SLOWS
DOWN WILL BE DIFFERENT DEPENDING

591

00:32:47,399 --> 00:32:49,167
ON WHETHER THERE'S A BIG CORE IN
THE MIDDLE OR NO CORE OR SMALLER

592
00:32:49,167 --> 00:32:49,467
CORE.

593
00:32:49,467 --> 00:32:54,372
WE COMBINE IT WITH THE WATER
MEASUREMENT TO FIT TOGETHER.

594
00:32:54,372 --> 00:32:56,474
WE CAN ALSO USE IT TO LOOK AT
ATMOSPHERIC DYNAMICS AND USE THE

595
00:32:56,474 --> 00:32:58,476
RADIO RECEIVERS TO DO THAT AS
WELL.

596
00:32:58,476 --> 00:33:06,117
SO WE SEE THESE BELTS AND ZONES
AND YOU CAN SEE HOW THEY MOVE

597
00:33:06,117 --> 00:33:07,619
RELATIVE TO EACH OTHER AND THE
GIANT STORM, THAT GREAT RED SPOT

598
00:33:07,619 --> 00:33:12,123
IS BIGGER THAN THE WHOLE EARTH.

599
00:33:12,123 --> 00:33:15,126
AND THAT PICTURE IS ABOUT TWICE
AS BIG AS THE EARTH, BUT IF YOU

600
00:33:15,126 --> 00:33:22,200
TOOK A PICTURE TODAY IT WOULD BE
MORE LIKE 1 1/2.

601
00:33:22,200 --> 00:33:22,734
IT'S BEEN SHRINKING.

602

00:33:22,734 --> 00:33:24,903

BEEN AROUND FOR HUNDREDS OF
YEARS AND WE'RE BEGINNING TO SEE

603

00:33:24,903 --> 00:33:27,539

IT SHRINK NOW.

604

00:33:27,539 --> 00:33:29,708

WE MIGHT BE ALIVE IN TIME TO SEE
IT DISAPPEAR.

605

00:33:29,708 --> 00:33:33,178

THOSE BELTS AND ZONES ARE MOVING
AT HIGH SPEED, SO AS THE PLANET

606

00:33:33,178 --> 00:33:38,149

ROTATES AROUND IF THEY HAVE A
LOT OF MAPS IN THERE DEEP OR I

607

00:33:38,149 --> 00:33:41,786

THEY'RE SHALLOW, THEN THEY'LL
HAVE A DIFFERENT GRAVITATIONAL

608

00:33:41,786 --> 00:33:45,490

SIGNATURE.

609

00:33:45,490 --> 00:33:46,958

AS THE SPACECRAFT FALLS PAST, IT
WILL SPEED UP AND SLOW DOWN AS

610

00:33:46,958 --> 00:33:52,764

IT FALLS DOWN IN A DIFFERENT
RATE, DIFFERENT WAY, DEPENDING

611

00:33:52,764 --> 00:33:53,331

ON HOW DEEP THEY GO.

612

00:33:53,331 --> 00:33:59,971

THIS IS AN ARTIST CONCEPTION,
BUT IMAGINE STRUCTURES THAT GO

613

00:33:59,971 --> 00:34:01,006

DEEP VERSUS THOSE THAT DON'T GO
DEEP.

614

00:34:01,006 --> 00:34:03,508

YOU'LL GET A DIFFERENT GRAVITY
SIGNATURE AND IT'S COMING FROM

615

00:34:03,508 --> 00:34:09,481

DEEP INSIDE THE ATMOSPHERE AND
HOW MUCH YOU SEE DEPENDING ON

616

00:34:09,481 --> 00:34:10,015

WHAT'S IN THE WAY.

617

00:34:10,015 --> 00:34:14,352

SO THE STRUCTURES WILL HAVE SOME
SIGNATURE IT IS, HOW DEEP IT IS

618

00:34:14,352 --> 00:34:16,288

DEPENDING ON HOW DEEP THE
STRUCTURE IS.

619

00:34:16,288 --> 00:34:19,491

SO WE LEARN NOW -- NOW WE'RE
PUTTING THE PICTURE TOGETHER.

620

00:34:19,491 --> 00:34:26,932

WE'RE USING MICROWAVES TO GET
THE WATER AND GET THE

621

00:34:26,932 --> 00:34:31,436

ATMOHERIC NAMICSE AND E
THEN WHAVE AAP OF JUPITER'S

622

00:34:31,436 --> 00:34:32,103

GNETICIELD.

623

00:34:32,103 --> 00:34:38,643

THIS LIQUID METALLIC HYDRON
EAN.

624

00:34:38,643 --> 00:34:42,781

YOU' GETTI TO TWMILLIO
MES THPRESSU UP TOHERE

625

00:34:42,781 --> 00:34:46,051

YOU CAN MAKE LIQUID METALLIC
HYDREN.

626

00:34:46,051 --> 00:34:49,788

SO BY MAPPING THE MAGNETIC FIELD
SINCE IT'S GENERATED BY THE

627

00:34:49,788 --> 00:34:52,324

METALLIC HYDROGEN, WE ARE
LEARNING ABOUT THE MOTION OF

628

00:34:52,324 --> 00:34:57,996

THAT AND SIZE OF THAT OCEAN OF
LIQUID METALLIC HYDROGEN.

629

00:34:57,996 --> 00:35:01,032

IT'S A GOLDEN OPPORTUNITY TO
ARN ABT HOW EY MAK

630

00:35:01,032 --> 00:35:06,004

MAGNET FIELD
E PLACTO LEA ABOUT

631

00:35:06,004 --> 00:35:13,445

PLETARY NAMO WRE MAGTIC
FIELDS IS HERE ON THE EARTH.

632

00:35:13,445 --> 00:35:18,316

ACCUCY, BUTHE MAETIC FLD
ON THE EARTH IS GENERATED BY THE

633

00:35:18,316 --> 00:35:21,786

MOLTEN IRON DOWN IN THE MIDDLE
AND IN BETWEEN AND THE CORE

634

00:35:21,786 --> 00:35:23,388

WHERE IT'S GENERATED, IN BETWEEN
US AND THE DYNAMO IS MAGNETIC

635

00:35:23,388 --> 00:35:27,392

MATIAL.

636

00:35:27,392 --> 00:35:30,729

SO WHAT WE MEASURE ON THE
SURFACE OF THE EARTH IS LIMITED

637

00:35:30,729 --> 00:35:33,298

NOT BY HOW WELL WE CAN MEASURE
IT, BUT BY HOW WELL IT

638

00:35:33,298 --> 00:35:34,899

RESENTSHE MAGTIC FID
THAT'SENERAT DOWN SIDE.

639

00:35:34,899 --> 00:35:39,804

ONUPITERHAT'S T A PRLEM.

640

00:35:39,804 --> 00:35:44,609

IT HYDRON IN BWEEN U
AND THDYNAMO, AND SOME HELIUM.

641

00:35:44,609 --> 00:35:45,844

T MAGNIC.

642

00:35:45,844 --> 00:35:52,217

IF WE ASURE E MAGNIC FIE
SURROUING THE PLANET WE'RE

643

00:35:52,217 --> 00:35:53,852

MEASURING DOWN TO THE DYNAMO
REGION.

644

00:35:53,852 --> 00:35:55,220

I DON'T KNOW IF YOU WERE
WATCHING THE MOVIE INSTEAD OF

645

00:35:55,220 --> 00:35:58,890

LISTENING TO ME, I HOPE, AND YOU
SAW THE TRACKS GO BY, THAT'S

646

00:35:58,890 --> 00:36:06,264

BECAUSE AS WE ORBIT THE PLANET
EVERY TWO WKS THEN THAT COUPLE

647

00:36:06,264 --> 00:36:08,066

HOURS FROM POLE TO POLE, JUPER
ISPINNINAROUNDVERY T

648

00:36:08,066 --> 00:36:11,136

SO WADJUSTHE TIMG JUST
TTLE AWE GO ST THELANET

649

00:36:11,136 --> 00:36:20,678

D EACH TIME WE COULDET A N
LONGITE STRI.

650

00:36:20,678 --> 00:36:22,113

ROTATE IT AROUND TO WHERE W
WA IT ANGET ANHER STKE

651

00:36:22,113 --> 00:36:22,480

PAST IT.

652

00:36:22,480 --> 00:36:23,882

SO THE TOUR WE HAVE SET UP,
THAT'S GOING TO GO INTO EFFECT

653

00:36:23,882 --> 00:36:30,288

ON THE 4th OF JULY DOES FOUR

STRIKES SO THAT YOU GET -- A

654

00:36:30,288 --> 00:36:31,790

STRIPE EVERY 90 DEGREES AND GET
A VERY ROUGH GLOBAL PICTURE OF

655

00:36:31,790 --> 00:36:32,190

THE PLANET.

656

00:36:32,190 --> 00:36:38,630

THEN FILL IN SO NOW YOU HAVE
EIGHT LONGITUDES AND YOU HAVE A

657

00:36:38,630 --> 00:36:39,631

BETTER GLOBAL VIEW OF THE
PLANET.

658

00:36:39,631 --> 00:36:47,172

THEN FILL IN AGAIN TO GET 16.

659

00:36:47,172 --> 00:36:47,906

AND THEN EVENTUALLY YOU GET 32.

660

00:36:47,906 --> 00:36:50,809

BY THE TIME WE'RE DONE, WE'LL
HAVE 32 LONGITUDES EVENLY SPACED

661

00:36:50,809 --> 00:36:52,877

AROUND THE PLANET MAKING A NET
WHERE WE'VE MEASURED THE

662

00:36:52,877 --> 00:36:54,245

MAGNETIC FIELD TO LEARN ABOUT
WHERE IT'S GENERATED DEEP

663

00:36:54,245 --> 00:36:57,415

INSIDE.

664

00:36:57,415 --> 00:36:57,882

ALL RIGHT.

665

00:36:57,882 --> 00:37:01,052

SO THAT TEACHES US ABOUT THE
CORE AND ABOUT THE COMPOSITION.

666

00:37:01,052 --> 00:37:04,956

A LOT OF THINGS BECAUSE IT
TEACHES US ABOUT THE SIZE OF THE

667

00:37:04,956 --> 00:37:05,990

DYNAMO REGION, HOW THE DYNAMO
WORKS.

668

00:37:05,990 --> 00:37:11,730

AND WHAT THOSE MOTIONS IN THERE
ARE.

669

00:37:11,730 --> 00:37:18,169

THEN FINALLY, THE MAGNETOSPHERE,
WE'RE IN A PERFECT ORBIT FOR

670

00:37:18,169 --> 00:37:19,437

STUDYING THE MAGNETOSPHERE.

671

00:37:19,437 --> 00:37:20,905

WE'RE COMING IN OVER THE POLE
AND JUPITER IF YOU LOOK AT THIS

672

00:37:20,905 --> 00:37:23,108

PICTURE, IN THE LOWER RIGHT,ws?
JUPITER LOOKS LIKE THIS GIANT

673

00:37:23,108 --> 00:37:27,412

MAGNET.

674

00:37:27,412 --> 00:37:29,948

PICTURE OF THE EARTH'S MAGNETIC
FIELD ONLY A LOT BIGGER.

675

00:37:29,948 --> 00:37:31,282

SO ALL OF THE MAGNETIC FIELD
LINES COME OUT LIKE THIS.

676

00:37:31,282 --> 00:37:31,983

AND AROUND.

677

00:37:31,983 --> 00:37:40,792

AND OUR TRAJECTORY TAKES US
ACROSS EVERY SINGLE FIELD LIN

678

00:37:40,792 --> 00:37:42,026

AND BACK OUT AGAIN.

679

00:37:42,026 --> 00:37:44,763

SO WE COME ACROSS THE DIFFERENT
LATITUDES THAT THERE ARE TO COME

680

00:37:44,763 --> 00:37:45,096

ACROSS.

681

00:37:45,096 --> 00:37:50,435

THAT MEANS YOU CAN BE UP HERE
MEASURE THE PARTICLES THAT ARE

682

00:37:50,435 --> 00:37:54,973

HITTING THE SPACECRAFTHILE
USING THE ULTRAVIOLET AND

683

00:37:54,973 --> 00:37:57,976

AURORA DOWN HERE AND SEE WHAT
THEY'RE DOING TO THE PLANET.

684

00:37:57,976 --> 00:38:00,545

THIS IS AN ULTRAVIOLET ICTURE.

685

00:38:00,545 --> 00:38:02,480

GET SOME IDEA OF WHAT THE AURORA
LOOK LIKE.

686

00:38:02,480 --> 00:38:07,819

YOU CAN SEE THAT'S A FOOTPRINT
OF IO.

687

00:38:07,819 --> 00:38:13,725

SO PICTURE OF VOLCANOES, SPEWING
STUFF OUT IN SPACE.

688

00:38:13,725 --> 00:38:17,362

THEY TRACK ALONG THE MAGNETIC
FIELD LINES AND THEY MAKE THE

689

00:38:17,362 --> 00:38:18,463

GLOW ON THE PLANET.

690

00:38:18,463 --> 00:38:21,366

BY MEASURING THAT GLOW THAT'S
ONE OF THE WAYS THAT WE FIGURED

691

00:38:21,366 --> 00:38:23,935

OUT SO FAR WHAT THE MAGNETIC
FIELD LOOKS LIKE.

692

00:38:23,935 --> 00:38:26,704

ONE OF THE BETTER MEASUREMENTS
FROM JUNO, OF COURSE.

693

00:38:26,704 --> 00:38:33,978

IF YOU'RE UP THERE ALONG THAT
MAGNETIC FIELD LINE AND YOU SEE

694

00:38:33,978 --> 00:38:35,380

THE PARTICLES HITTING THE
SPACECRAFT, YOU KNOW WHAT KIND

695

00:38:35,380 --> 00:38:38,716

OF ENERGIES AND SO FORTH THAT
ARE GETTING DOWN TO PLANET AND

696

00:38:38,716 --> 00:38:40,185

YOU'RE SORT OF IN A PERFECT
VANTAGE POINT TO UNDERSTAND HOW

697

00:38:40,185 --> 00:38:44,689

ARE THE AURORA ARE FORMED.

698

00:38:44,689 --> 00:38:47,058

IF YOU WANT TO STUDY SOMETHING
OUT HERE IN THE MAGNETOSPHERE

699

00:38:47,058 --> 00:38:47,792

YOU'RE CROSSING THOSE LINES TOO.

700

00:38:47,792 --> 00:38:54,999

THIS IS A GREAT WAY, A GREAT
LOCATION FOR THE FIELDS OF THE

701

00:38:54,999 --> 00:38:55,567

PARTICLE INSTRUMENTS.

702

00:38:55,567 --> 00:38:56,768

I'M ALMOST READY FOR YOU GUYS TO
ASK QUESTIONS.

703

00:38:56,768 --> 00:39:04,976

LET ME GET DOWN TO THE NEXT ONE,
WHICH IS REMEMBER I PROMISED TO

704

00:39:04,976 --> 00:39:06,110

TELL YOU MORE ABOUT THE VISIBLE
CAMERA?

705

00:39:06,110 --> 00:39:06,711

SO IT'S CALLED JUNO CAM.

706

00:39:06,711 --> 00:39:12,984

AND IT WILL TAKE GREAT PICTURES
OF THE POLES OF JUPITER.

707

00:39:12,984 --> 00:39:18,890

SORT OF DESIGNED THAT WAY TO BE
ABLE TO GET PICTURES OF THAT

708

00:39:18,890 --> 00:39:21,025

POLAR REGION OF NORTH AND SOUTH
WHERE WE DON'T HAVE ANY GOOD

709

00:39:21,025 --> 00:39:21,392

CTURES.

710

00:39:21,392 --> 00:39:24,495

BUT IT'S ALSO DESIGNED IN THE
WAY WE'RE USING IT IS DESIGNED

711

00:39:24,495 --> 00:39:29,634

TO DO WHAT WE'RE CALLING SCIENCE
IN FISH BOWL.

712

00:39:29,634 --> 00:39:33,371

AND BASIC IDEA IS WE WANT TO DO
SCIENCE OUT IN THE OPEN WITH

713

00:39:33,371 --> 00:39:34,706

EVERYBODY WHO WANTS TO
PARTICIPATE AND SEEING WHAT'S

714

00:39:34,706 --> 00:39:37,575

GOING ON AND BEING PART OF IT.

715

00:39:37,575 --> 00:39:44,015

SO IF YOU GO TO OUR MISSION JUNO
WEBSITE RIGHT NOW, ONE OF THE

716

00:39:44,015 --> 00:39:45,450

THINGS THERE IS THIS PAGE FOR
JUNO CAM THAT I'MHOWING YOU

717

00:39:45,450 --> 00:39:51,623
IT HAS AN OPPORTUNITY FOR PEOPLE
TO UPLOAD PICTURES OF JUPITER,

718
00:39:51,623 --> 00:39:52,323
TAKEN FROM HERE ON THE EARTH.

719
00:39:52,323 --> 00:39:57,729
WHICH WILL BE USED TO MAKE THE
MAP BECAUSE JUPITER CHANGES, YOU

720
00:39:57,729 --> 00:40:01,266
NEED TO GET CURRENT PICTURES OF
JUPITER TO MAKE THE MAP THAT'S

721
00:40:01,266 --> 00:40:04,802
USED FOR PEOPLE TO LOOK AT THE
MAP AND PICK OUT SPOTS AND SAY,

722
00:40:04,802 --> 00:40:09,474
TAKE A PICTURE OF THIS.

723
00:40:09,474 --> 00:40:10,708
THIS LOOKS INTERESTING, TAKE A
PICTURE OF THAT.

724
00:40:10,708 --> 00:40:12,844
THEN THERE WILL BE A DISCUSSION
SECTION WHERE PEOPLE CAN ARGUE

725
00:40:12,844 --> 00:40:13,344
ABOUT IT.

726
00:40:13,344 --> 00:40:17,348
TH-6o SCIENTISTS, YOU KNOW, IF E
SCIENTISTS WANT US TO TAKE A

727
00:40:17,348 --> 00:40:18,750
PICTURE OF SOME PARTICULAR
OBJECT, GO TO THE WEBSITE, PUT

728

00:40:18,750 --> 00:40:21,853

IT IN, YOU KNOW, COMPETE WITH
MRS. FIELDS THIRD GRADE CLASS TO

729

00:40:21,853 --> 00:40:26,457

MAKE A GOOD CASE FOR IT.

730

00:40:26,457 --> 00:40:27,659

AND THEN THERE WILL BE A SYSTEM
OF VOTING.

731

00:40:27,659 --> 00:40:34,032

WHERE THE PUBLIC CAN VOTE ON
WHICH PICTURES SHOULD BE TAKEN.

732

00:40:34,032 --> 00:40:35,533

WE'LL TAKE THAT INTO ACCOUNT IN
CHOOSING THE PICTURES SO WE HOPE

733

00:40:35,533 --> 00:40:40,505

TO HAVE A GOOD SCIENTIFIC
DISCUSSION ABOUT IT, PROBABLY

734

00:40:40,505 --> 00:40:41,673

MIXED IN WITH COMMENTS LIKE THAT
WAS PRETTY.

735

00:40:41,673 --> 00:40:44,676

WHICH IS OKAY.

736

00:40:44,676 --> 00:40:51,482

WE HAVE A LIMITED NUMBER OF
PICTURES WE CAN TAKE AND SO WE

737

00:40:51,482 --> 00:40:53,351

WANT TO CHOOSE THE BEST ONES.

738

00:40:53,351 --> 00:40:58,656

THIS IS HOW SCIENTISTS WOULD
NORMALLY DO IT, HAVE THE DEBATE

739

00:40:58,656 --> 00:41:03,127
OVER WHAT'S THE BEST IMAGE,
WHAT'S THE BEST WAY TO SPIN

740

00:41:03,127 --> 00:41:03,528
THOSE BITS.

741

00:41:03,528 --> 00:41:07,532
THOSE COMMUNICATION CAPABILITIES
AND THE ONLY THING IS ANYBODY

742

00:41:07,532 --> 00:41:09,467
WHO WANTS TO PARTICIPATE CAN
PARTICIPATE IN THE DISCUSSION.

743

00:41:09,467 --> 00:41:14,205
WHEN WE FINALLY TAKE THE
PICTURES WE'LL TAKE THE RAW DATA

744

00:41:14,205 --> 00:41:18,109
AND PUT IT OUT ON THE WEB.

745

00:41:18,109 --> 00:41:19,510
THERE MIGHT BE PROFESSIONALS
TRYING TO PROCESS THAT TOO.

746

00:41:19,510 --> 00:41:24,015
BUT ANYBODY WHO WANTS TO TAKE
THE RAW DATA CAN TURN IT INTO

747

00:41:24,015 --> 00:41:27,085
PICTURES TO SHOW US WHAT YOU'VE
GOT.

748

00:41:27,085 --> 00:41:32,690
WE GOT THAT WHEN WE FLEW PAST
EARTH.

749

00:41:32,690 --> 00:41:34,058

WE FLEW PAST THE EARTH AND JUNO
CAM TOOK SOME PICTURES.

750

00:41:34,058 --> 00:41:37,662

WE WEREN'T READY FOR THE
PLANNING AND DISCUSSION AND

751

00:41:37,662 --> 00:41:38,496

VOTING DISCUSSION YET.

752

00:41:38,496 --> 00:41:44,569

SO WE PUT IT OUT ON THE WEB AND
IN LESS THAN 24 HOURS WE HAD

753

00:41:44,569 --> 00:41:48,906

AMAZING PICTURES THAT PEOPLE
TOOK THE RAW DATA AND TURNED IT

754

00:41:48,906 --> 00:41:52,110

INTO A PICTURE.

755

00:41:52,110 --> 00:41:53,611

NOT LIKE TAKING THE PICTURE OUT
OF YOUR CELL PHONE AND PUTTING

756

00:41:53,611 --> 00:41:58,249

IT UP AND YOU HAVE A GOOD
PICTURE.

757

00:41:58,249 --> 00:41:59,784

THE WAY THE CAMERA WORKS ITS HAS
TO TAKE THREE DIFFERENT IMAGES

758

00:41:59,784 --> 00:42:04,856

TO GET THREE DIFFERENT COLORS,
WE HAVE A FILTER ON THERE AS

759

00:42:04,856 --> 00:42:05,156

WELL.

760

00:42:05,156 --> 00:42:06,224

METHANE FILTER.

761

00:42:06,224 --> 00:42:08,526

SO FOUR IMAGES IN DIFFERENT
COLORS.

762

00:42:08,526 --> 00:42:09,927

IT IS NOT TAKE THE WHOLE IMAGE
ALL AT ONCE, SO YOU TAKE A

763

00:42:09,927 --> 00:42:15,199

LITTLE BAR AND YOU TAKE INTO
ACCOUNT THE FACT THAT THE

764

00:42:15,199 --> 00:42:16,267

SPACECRAFT IS ROTATING AND PULL
IT OUT.

765

00:42:16,267 --> 00:42:22,340

THEN YOU HAVE TO TURN THAT INTO
A PICTURE.

766

00:42:22,340 --> 00:42:28,846

AND YOU'RE GOING OVER JUPITER OR
IN THE CASE OF THE EARTH -- FLY

767

00:42:28,846 --> 00:42:35,086

BY THE EARTH WHICH IS A SPHERE
MORE OR LESS AND EVERYTHING IS

768

00:42:35,086 --> 00:42:36,554

DISTORTED AND YOU HAVE TO PUT
THE DIFFERENT COLORS TOGETHER.

769

00:42:36,554 --> 00:42:38,256

TO ME IT'S ABSOLUTELY

FLABBERGASTING THERE ARE PEOPLE

770

00:42:38,256 --> 00:42:40,491

OUT THERE WHO DID ALL THAT FOR
FUN.

771

00:42:40,491 --> 00:42:43,261

IT'S NOT THEIR JOB, BUT THEY
BECAME EXPERTS ON IT BECAE

772

00:42:43,261 --> 00:42:43,928

IT'S FUN TO LEARN ABOUT IT.

773

00:42:43,928 --> 00:42:45,430

AND THEY LIKE TO BE PART OF IT
AND THEY WERE REALLY EXCITED TO

774

00:42:45,430 --> 00:42:46,030

BE PART OF THE PROJECT.

775

00:42:46,030 --> 00:42:52,403

SO WE HAVE -- WE EXPECT TO HAVE
MORE PEOPLE WHEN THERE ARE

776

00:42:52,403 --> 00:42:54,572

PICTURES OF JUPITER DOING THAT.

777

00:42:54,572 --> 00:42:56,274

AND WHO KNOWS, MAYBE SOME OF YOU
GUYS IN THE AUDIENCE WILL DECIDE

778

00:42:56,274 --> 00:42:57,408

TO GO TAKE A LOOK TO SEE WHAT
YOU CAN DO.

779

00:42:57,408 --> 00:43:00,144

OKAY.

780

00:43:00,144 --> 00:43:07,018

SO I'M ALMOST DONE, READY FOR
QUESTIONS.

781

00:43:07,018 --> 00:43:12,523

THE LAST THING IS EYES ON THE
SOLAR SYSTEM.

782

00:43:12,523 --> 00:43:14,959

I HOPE A LOT OF YOU HAVE HEARD
OF THAT ALREADY.

783

00:43:14,959 --> 00:43:18,529

IT'S NASA'S 3-D INTERACTIVE WAY
OF FINDING OUT ABOUT WHAT WE

784

00:43:18,529 --> 00:43:20,465

HAVE OUT THERE IN THE SOLAR
SYSTEM.

785

00:43:20,465 --> 00:43:21,098

THE WEBSITE IS UP THERE.

786

00:43:21,098 --> 00:43:23,568

THERE'S LOTS OF COOL STUFF ABOUT
JUNO THERE.

787

00:43:23,568 --> 00:43:24,202

AND WE HAVE TWO WEBSITES.

788

00:43:24,202 --> 00:43:33,678

WE HAVE THE MISSION WEBSITE
WHICH IS VIDEOS AND MOVIES AND

789

00:43:33,678 --> 00:43:39,650

THE JUNO CAM SITE AND INTERVIEWS
WITH PEOPLE ON THE PROJECT AND

790

00:43:39,650 --> 00:43:41,085

ALL THE COOL PROJECTS STUFF THAT
WE COULD THINK OF THAT WE

791

00:43:41,085 --> 00:43:42,153

THOUGHT WOULD BE FUN AND MORE TO
COME.

792

00:43:42,153 --> 00:43:43,621

WE HAVE THE MAIN MAP OF THE
WEBSITE WHICH HAS THE SECTION

793

00:43:43,621 --> 00:43:47,425

FOR JUNO AND OF COURSE LINKS TO
EACH OTHER.

794

00:43:47,425 --> 00:43:47,825

ALL RIGHT.

795

00:43:47,825 --> 00:43:55,766

NOW FINALLY WE'RE READY FOR
QUESTIONS.

796

00:43:55,766 --> 00:43:57,168

I HOPE YOU HAVE LOTS OF
QUESTIONS, BECAUSE THAT'S THE

797

00:43:57,168 --> 00:43:57,902

FAVORITE PART OF ANY TALK.

798

00:43:57,902 --> 00:43:58,636

THERE'S A MICROPHONE OVER THERE.

799

00:43:58,636 --> 00:43:59,203

IF ANYBODY IS READY.

800

00:43:59,203 --> 00:44:08,045

[APPLAUSE]

>> I DON'T KNOW IF THERE'S A

801

00:44:14,619 --> 00:44:16,420

MODERATOR OR SOMEBODY IF I GET

TO CHOOSE WHOEVER IS FIRST IN

802

00:44:16,420 --> 00:44:16,854

LINE, I GUESS.

803

00:44:16,854 --> 00:44:18,189

GO AHEAD.

>> OKAY.

804

00:44:18,189 --> 00:44:23,394

SO A TWO-PART QUESTION HERE.

805

00:44:23,394 --> 00:44:28,966

SO WHAT DO YOU MEAN BY
RECOVERING AFTER JUNO PASSES BY

806

00:44:28,966 --> 00:44:30,368

THE RADIATION BELT?

807

00:44:30,368 --> 00:44:35,673

AND DO YOU PREDICT THAT IT WILL
DECREASE IF THE HIGH ENERGY

808

00:44:35,673 --> 00:44:38,109

ELECTRONS DISPERSE?

809

00:44:38,109 --> 00:44:40,211

>> LET'S DO THE FIRST PART OF
THAT.

810

00:44:40,211 --> 00:44:46,417

WHAT I MEAN BY RECOVERING AFTER
WE GET BY THE RADIATION BELT,

811

00:44:46,417 --> 00:44:47,785

NOT SO MUCH THE RADIATION
ALTHOUGH IT'S POSSIBLE WE'LL

812

00:44:47,785 --> 00:44:50,555

HAVE SOME PROBLEMS AND WE'LL
NEED TO FIGURE THEM OUT.

813

00:44:50,555 --> 00:44:55,693

BUT WE THINK WE HAVE DESIGNED IT
ALL TO GO THROUGH THE GAP OF THE

814

00:44:55,693 --> 00:44:59,430

RADIATION BELT AND THE PLANET
WITHOUT HAVING ANY MAJOR

815

00:44:59,430 --> 00:44:59,797

PROBLEM.

816

00:44:59,797 --> 00:45:02,900

HOWEVER, WE'RE GOING TO COLLECT
A WHOLE BUNCH OF DATA RIGHT

817

00:45:02,900 --> 00:45:03,701

CLOSE TO JUPITER.

818

00:45:03,701 --> 00:45:11,609

WE THINK OF IT AS A FLY-BY AS 32
FLY-BYES RATHER THAN ORBITS.

819

00:45:11,609 --> 00:45:14,712

SO WE COLLECT ALL THE DATA, THEN
WE HAVE TO SEND IT BACK TO THE

820

00:45:14,712 --> 00:45:19,917

EARTH, SO WE EXPEND A BUNCH OF
POWER AND WE'RE SOLAR POWERED TO

821

00:45:19,917 --> 00:45:20,251

JUPITER.

822

00:45:20,251 --> 00:45:25,856

SO IF YOU RUN THE WHOLE
SPACECRAFT ON ABOUT A THIRD OR A

823

00:45:25,856 --> 00:45:29,093

FOURTH OF WHAT IT TAKES TO RUN A
HAIR DRYER.

824

00:45:29,093 --> 00:45:29,393

OKAY?

825

00:45:29,393 --> 00:45:34,799

SO WE'LL USE ALL THAT POWER
WE'LL DRAIN THE BATTERY SOME.

826

00:45:34,799 --> 00:45:36,567

WE'LL TRANSMIT TO THE GROUND AND
THAT DRAINS THE POWER, SO WE

827

00:45:36,567 --> 00:45:37,068

NEED TO RECOVER.

828

00:45:37,068 --> 00:45:46,310

SO WE NEED TO FILL UP THE
BATTERY -- YOU KNOW, CHARGE THE

829

00:45:46,310 --> 00:45:47,478

BATTERY AGAIN SO WE NEED SOME
TIME FOR THAT.

830

00:45:47,478 --> 00:45:48,679

WE NEED TO TRANSMIT ALL THE DAY
TO THE GROUND.

831

00:45:48,679 --> 00:45:49,347

WE NEED SOME TIME FOR THAT.

832

00:45:49,347 --> 00:45:53,784

THEN THE PEOPLE ON THE GROUND
NEED SOME TIME TO PROCESS WHAT

833

00:45:53,784 --> 00:45:56,020

THE HECK JUST HAPPENED AND WHAT

DID WE LEARN SO THAT WHEN WE GO

834

00:45:56,020 --> 00:45:57,355

AROUND AGAIN WE'RE MEASURING
WHAT WE WANT TO MEASURE.

835

00:45:57,355 --> 00:46:03,828

NOW HAVE -- NOW, I'M CHEATING A
LITTLE BIT BECAUSE PROBABLY WE

836

00:46:03,828 --> 00:46:12,103

WON'T MAKE VERY MANY CHANGES IN
THE 14 DAYS WE'LL HAVE FROM ONE

837

00:46:12,103 --> 00:46:13,037

JOVIAN PASS TO THE NEXT.

838

00:46:13,037 --> 00:46:13,771

IT'S VERY FAST.

839

00:46:13,771 --> 00:46:17,174

BY THE TIME YOU FIGURE OUT WHAT
YOU HAVE SEEN, HEY, I WANT TO

840

00:46:17,174 --> 00:46:19,377

MEASURE SOMETHING ELSE IT'S TOO
LATE TO SEND IT UP AND MEASURE

841

00:46:19,377 --> 00:46:20,611

IT FOR THE VERY NEXT PASS, BUT
WE HAVE A PROCESS.

842

00:46:20,611 --> 00:46:23,281

TWO OR THREE OR FOUR PASSING
LATER, WE COULD BE MAKING

843

00:46:23,281 --> 00:46:27,118

CHANGES BASED ON THAT.

844

00:46:27,118 --> 00:46:29,320
OR IF SOMETHING IS REALLY
IMPORTANT, MAYBE WE CAN DO IT

845
00:46:29,320 --> 00:46:30,254
RIGHT AWAY.

846
00:46:30,254 --> 00:46:31,656
ALL OF THAT, THAT TWO WEEKS IS
WHAT I MEANT BY RECOVER.

847
00:46:31,656 --> 00:46:43,901
NOW, IN TERMS OF THE RADIATION
BELTS AND THE ELECTRONS

848
00:46:43,901 --> 00:46:47,304
DISPERSING, THE HIGH ENERGY ONES
ARE THE MOST DANGEROUS.

849
00:46:47,304 --> 00:46:50,541
IF THEY WERE TO DISPERSE THEY'RE
MOST DANGEROUS.

850
00:46:50,541 --> 00:46:56,681
BUT WE HAVE A GOOD IDEA OF WHERE
THEY ARE.

851
00:46:56,681 --> 00:46:58,149
NOT A PERFECT PICTURE BUT
REMEMBER I SHOWED YOU THE RADIO

852
00:46:58,149 --> 00:47:00,685
RECEIVER, WHAT JUPITER LOOKED
LIKE AND WE COULD SEE THE

853
00:47:00,685 --> 00:47:02,153
RADIATION BELT IN THE RADIO.

854
00:47:02,153 --> 00:47:06,223
IT'S COMPLICATED TO GO FROM WHAT

I SEE IN THE RADIO TO WHAT THAT

855

00:47:06,223 --> 00:47:13,064

MEANS FOR HIGH ENERGY ELECTRONS
BUT WE HAVE A GOOD ENOUGH

856

00:47:13,064 --> 00:47:15,099

PICTURE THAT WE HAVE A GOOD IDEA
OF WHERE THEY ARE AND OF COURSE

857

00:47:15,099 --> 00:47:17,068

WE'LL GET GREAT MEASUREMENTS
WHEN WE'RE THERE.

858

00:47:17,068 --> 00:47:17,668

THANKS FOR THE QUESTION.

859

00:47:17,668 --> 00:47:18,969

OH, THAT REMINDS ME, ACTUALLY,
SPEAKING OF THE RADIO.

860

00:47:18,969 --> 00:47:24,141

THERE'S ANOTHER PROJECT LOOSELY
ASSOCIATED WITH US CALLED

861

00:47:24,141 --> 00:47:30,981

GABBERT, IN WHICH SCHOOL KIDS
ARE USING THE RADIO TELESCOPE TO

862

00:47:30,981 --> 00:47:34,118

COLLECT RADIO DATA ON JUPITER
AND SOME OF THAT DATA GOES INTO

863

00:47:34,118 --> 00:47:39,490

THE MODEL TO FIGURE OUT WHERE
THE RADIATION BELTS ARE.

864

00:47:39,490 --> 00:47:40,858

SO WE HAVE SCHOOL KIDS ALL OVER
THE COUNTRY RUNNING THE

865

00:47:40,858 --> 00:47:45,563

TELESCOPE OVER THE INTERNET,
HELPING US WITH THE RADIATION

866

00:47:45,563 --> 00:47:46,697

BELT MODEL.
>> THANK YOU.

867

00:47:46,697 --> 00:47:52,770

>> YEAH, YOU MENTIONED THAT WHAT
WE SEE OF JUPITER ISN'T JUPITER,

868

00:47:52,770 --> 00:47:54,205

IT'S REALLY JUST THE AURORA
BOREALIS AND THE RADIATION THAT

869

00:47:54,205 --> 00:47:58,209

GOES AROUND THERE.

870

00:47:58,209 --> 00:48:01,245

DID I MISUNDERSTAND AND IF I DID
MISUNDERSTAND, HOW LONG HAVE WE

871

00:48:01,245 --> 00:48:01,645

KNOWN THAT?

872

00:48:01,645 --> 00:48:07,151

AND IF WE KNOW THAT, WHEN DID WE
DISCOVER THAT AND THEN HOW DO WE

873

00:48:07,151 --> 00:48:11,989

PROJECT WHAT THE JUPITER
ACTUALLY LOOKS LIKE INSIDE THE

874

00:48:11,989 --> 00:48:15,326

PART THAT WE CAN'T SEE?

875

00:48:15,326 --> 00:48:20,798

>> OKAY.
>> UP TO THIS POINT.

876
00:48:20,798 --> 00:48:21,332
>> SO YOU'RE CLOSE.

877
00:48:21,332 --> 00:48:23,534
BUT WHAT I'M SAYING IS WHAT WE
SEE OF JUPITER IS THE TOPS OF

878
00:48:23,534 --> 00:48:24,668
THE CLOUDS OF THE ATMOSPHERE.

879
00:48:24,668 --> 00:48:28,172
SO WHEN YOU LOCK AT THIS
PICTURE -- LOOK AT THIS PICTURE

880
00:48:28,172 --> 00:48:29,640
HERE, I'LL USE THE POINTER TO
POINT AT THINGS, THAT'S A STORM,

881
00:48:29,640 --> 00:48:32,610
IT'S HUGE.

882
00:48:32,610 --> 00:48:34,078
PROBABLY HUNDREDS OF MILES DEEP
BUT THAT'S NOTHING COMPARED TO

883
00:48:34,078 --> 00:48:41,018
THE SIZE OF JUPITER AND ITS
CLOUDS MOVING AROUND IN THE

884
00:48:41,018 --> 00:48:41,786
UPPER ATMOSPHERE.

885
00:48:41,786 --> 00:48:43,454
WHEN WE SEE THE AURORA WHICH ARE
IN A DIFFERENT PICTURE I HAVE ON

886

00:48:43,454 --> 00:48:49,126
HERE, THAT ONE, SO THAT'S AN
ULTRAVIOLET IMAGE.

887
00:48:49,126 --> 00:49:00,504
NOT AS EASY TO SEE THEM IN
REGULAR VISIBLE LIGHT ALTHOUGH

888
00:49:00,504 --> 00:49:00,871
YOU CAN.

889
00:49:00,871 --> 00:49:02,373
YOU'RE SEEING EVEN HIGHER IN THE
ATMOSPHERE OF JUPITER GLOWING IN

890
00:49:02,373 --> 00:49:02,840
THE ULTRAVIOLET.

891
00:49:02,840 --> 00:49:06,076
WE CAN SEE BELOW THAT, WE CAN
SEE IN THE UPPER ATMOSPHERE.

892
00:49:06,076 --> 00:49:08,145
WE CAN'T SEE THROUGH THE CLOUDS
TO SEE WHAT ELSE IS THERE.

893
00:49:08,145 --> 00:49:11,148
WE HAVE NOPE THAT FOR A LONG
TIME THERE.

894
00:49:11,148 --> 00:49:11,916
I DON'T KNOW HOW LONG.

895
00:49:11,916 --> 00:49:14,318
BUT IT'S DECADES, MAYBE EVEN A
HURED YEARS.

896
00:49:14,318 --> 00:49:14,985
>> YEAH.

897

00:49:14,985 --> 00:49:17,988

OKAY, SO IF YOU LOOK THROUGH A
TELESCOPE, THAT'S WHAT YOU'RE

898

00:49:17,988 --> 00:49:20,891

ACTUALLY SEEING, YOU'RE NOT
SEEING THE PLANET?

899

00:49:20,891 --> 00:49:22,026

YOU'RE --

>> YOU'RE SEEING THE ATMOSPHERE.

900

00:49:22,026 --> 00:49:22,726

THE ATMOSPHERE IS THE PLANET.

901

00:49:22,726 --> 00:49:28,466

REMEMBER, IT'S ENTIRELY POSSIBLE
THAT JUPITER DOESN'T HAVE A CORE

902

00:49:28,466 --> 00:49:29,700

DOWN IN THE MIDDLE.

903

00:49:29,700 --> 00:49:30,234

WE THINK IT SHOULD.

904

00:49:30,234 --> 00:49:31,368

BUT MAYBE THE ENTIRE PLANET IS
ATMOSPHERE.

905

00:49:31,368 --> 00:49:34,572

THAT'S A POSSIBILITY.

906

00:49:34,572 --> 00:49:36,140

>> OKAY.

>> YES, YOU'RE SEEING THE

907

00:49:36,140 --> 00:49:37,641

ATMOSPHERE, BUT I WOULDN'T SAY
YOU'RE SEEING THE ATMOSPHERE NOT

908

00:49:37,641 --> 00:49:38,042

THE PLANET.

909

00:49:38,042 --> 00:49:42,046

I WOULD SAY THE ATMOSPHERE IS
THE PLANET OR AT LEAST A BIG

910

00:49:42,046 --> 00:49:44,748

PART OF IT.

>> OKAY, THANKS.

911

00:49:44,748 --> 00:49:45,249

>> GOOD EVENING.

912

00:49:45,249 --> 00:49:49,920

GREAT TALK.

913

00:49:49,920 --> 00:49:56,594

YOU MENTIONED THAT THE --
THERE'S GIANT SOLAR PANELS THAT

914

00:49:56,594 --> 00:49:58,829

WILL GENERATE 500 KILOWATTS
WHICH IS AMAZING --

915

00:49:58,829 --> 00:50:02,199

>> WATTS.

>> 500 WATTS, YEAH, THAT WOULD

916

00:50:02,199 --> 00:50:02,566

BE GREAT.

917

00:50:02,566 --> 00:50:04,068

DO YOU THINK IT'S POSSIBLE THAT
THE VERY BRIGHTNESS OF JUPITER

918

00:50:04,068 --> 00:50:13,444

ITSELF MIGHT BE ABLE TO WORK

WITH THOSE PANELS TO GENERATE

919

00:50:13,444 --> 00:50:14,745

SOME ELECTRICITY?

920

00:50:14,745 --> 00:50:18,816

>> IT WOULD BE A PRETTY TINY
AMOUNT OF ELECTRICITY FROM

921

00:50:18,816 --> 00:50:24,188

JUPITER AND IN GENERAL THE
PANELS AREN'T POINTING AT

922

00:50:24,188 --> 00:50:24,522

JUPITER.

923

00:50:24,522 --> 00:50:26,023

WE KEEP THEM POINTED AT THE SUN
AND THE ORBIT WE'RE IN IS KIND

924

00:50:26,023 --> 00:50:26,457

OF CROSSWISE.

925

00:50:26,457 --> 00:50:31,161

SO THINK OF A SPINNING PROPELLER
GOING AROUND THE PLANET.

926

00:50:31,161 --> 00:50:33,097

ALWAYS POINTED AT THE SUN AND
TRAVELING DOWN PRETTY CLOSE TO

927

00:50:33,097 --> 00:50:42,306

THAT DAWN/DUSK LINE WHERE THE
FRONT PART OF JUPITER AS SEEN

928

00:50:42,306 --> 00:50:44,475

FROM THE EARTH IS LIT UP AND THE
PLANET IS GOING SIDEWAYS AROUND

929

00:50:44,475 --> 00:50:44,742

IT.

930

00:50:44,742 --> 00:50:49,747

SO THE SOLAR PANELS ARE EDGE ON
TO THE PLANET.

931

00:50:49,747 --> 00:50:52,750

BUT IN FACT THE AMOUNT OF LIGHT
YOU GET FROM JUPITER IS PRETTY

932

00:50:52,750 --> 00:50:58,622

I HAVE CARDS HERE FROM PEOPLE
CONTACTING US OVER THE INTERNET.

933

00:50:58,622 --> 00:51:04,094

SO IF SOMEBODY -- ONE ASKS, IF
IT ONLY TAKES A COUPLE HOURS

934

00:51:04,094 --> 00:51:07,765

FROM POLE TO POLE, HOW FAST IS
JUNO GOING?

935

00:51:07,765 --> 00:51:14,271

SO THE SHORT ANSWER IS I DON'T
KNOW.

936

00:51:14,271 --> 00:51:15,673

THE LONGER ANSWER IS IT'S ABOUT
30 KILOMETERS A SECOND.

937

00:51:15,673 --> 00:51:21,879

ANDéy AN EVEN LONGER ANSWE
HAVE TO SAY HOW FAST IS IT GOING

938

00:51:21,879 --> 00:51:23,714

COMPARED TO WHAT?R YOU LONGER A
SO IF I WANT TO COMPARE THE

939

00:51:23,714 --> 00:51:31,288

SPEED OF ■ç JUNO TO JUPITER, I
THINK THAT'S A NUMBER THAT'S IN

940
00:51:31,288 --> 00:51:33,190
THE NEIGHBORHOOD OF 30
KILOMETERS A SECOND.

941
00:51:33,190 --> 00:51:34,692
BUT OF COURSE JUPITER'S MOVING
AND THE EARTH IS MOVING AND THE

942
00:51:34,692 --> 00:51:35,125
SUN IS MOVING.

943
00:51:35,125 --> 00:51:37,227
AND THE GALAXY IS MOVING.

944
00:51:37,227 --> 00:51:43,734
SO TAKE YOUR PICK.

945
00:51:43,734 --> 00:51:45,235
I -- FOR A WHILE THERE WE WERE
LOOKING AT TRYING TO COMPARE THE

946
00:51:45,235 --> 00:51:51,609
SPEED OF JUNO WITH THE LAUNCH
PAD ON THE EARTH FROM WHICH IT

947
00:51:51,609 --> 00:51:51,976
LAUNCHED.

948
00:51:51,976 --> 00:51:56,447
SO THE EARTH SPINNING AND MOVING
AND JUNO IS MOVING AND JUPITER

949
00:51:56,447 --> 00:52:04,288
IS MOVING AND ALL THAT, AND WE
PICKED THAT BECAUSE ACTUALLY OUR

950

00:52:04,288 --> 00:52:10,094
P.I. REALIZED THAT IF YOU PICKED
THAT REALIZED THAT YOU HAVE A

951
00:52:10,094 --> 00:52:12,096
DECENT CASE OF JUNO IS THE
FASTEST THING EVER BUILT BY

952
00:52:12,096 --> 00:52:12,429
PEOPLE.

953
00:52:12,429 --> 00:52:18,068
YOU KNOW, CHOOSE YOUR REFERENCE
POINT.

954
00:52:18,068 --> 00:52:20,571
>> THANK YOU FOR A TERRIFIC
TALK.

955
00:52:20,571 --> 00:52:23,374
A QUESTION ABOUT THE AMOUNT OF
DATA THAT YOU CAN TRANSMIT SOME.

956
00:52:23,374 --> 00:52:30,214
DO YOU HAVE TO DO A LOT OF ON
BOARD PROCESSING OF THE

957
00:52:30,214 --> 00:52:30,647
INSTRUMENTS?

958
00:52:30,647 --> 00:52:31,081
>> OKAY.

959
00:52:31,081 --> 00:52:36,520
SO FOR THE FIRST QUESTION, I GET
TO SAY I DON'T KNOW AGAIN.

960
00:52:36,520 --> 00:52:37,788
BUT ACTUALLY, IT'S A FEW
GIGABITS, NOT BYTES, BUT

961
00:52:37,788 --> 00:52:38,155
GIGABITS.

962
00:52:38,155 --> 00:52:46,897
SO THE ENTIRE OUTPUT OF THE JUNO
SPACECRAFT FROM BEGINNING TO END

963
00:52:46,897 --> 00:52:48,265
PROBABLY FITS ON MY LAPTOP OR
PRETTY CLOSE TO IT ANYWAY.

964
00:52:48,265 --> 00:52:52,603
AND IT'S STILL A HUGE AMOUNT OF
DATA, BUT REMEMBER WE'RE SENDING

965
00:52:52,603 --> 00:52:53,270
IT ALL THE WAY FROM JUPITER.

966
00:52:53,270 --> 00:52:56,974
SO IT -- YOU CAN'T SEND IT
REALLY FAST.

967
00:52:56,974 --> 00:53:07,484
IT'S NOT LIKE, YOU KNOW, WI-FI
HERE IN THE ROOM.

968
00:53:07,484 --> 00:53:08,919
AND ALSO, THE COMPUTER THAT
FLIES NOT ONLY DO WE LAUNCH I

969
00:53:08,919 --> 00:53:11,622
WANT IN 2011 BUT WE HAD TO BUILD
IT A FEW YEARS BEFORE AND WE HAD

970
00:53:11,622 --> 00:53:12,956
TO BE SURE IT WAS GOING TO WORK
IN SPACE AND RADIATION

971

00:53:12,956 --> 00:53:16,460
ENVIRONMENT SO IT'S ALSO THE
COMPUTER IS QUITE A BIT OLDER.

972
00:53:16,460 --> 00:53:20,030
HAVING SAID ALL OF THAT, YOU
KNOW, THE MOST IMPORTANT THING

973
00:53:20,030 --> 00:53:28,572
WE WANT TO MEASURE IS PROBABLY
THE GLOBAL WATER ABUNDANCE ON

974
00:53:28,572 --> 00:53:29,540
JUPITER THAT'S ONE NUMBER.

975
00:53:29,540 --> 00:53:30,374
A FEW BYTES.
>> THANKS.

976
00:53:30,374 --> 00:53:37,081
>> WITH ALL OF THE MAGNETIC
FIELDS AND RADIATION AROUND IT

977
00:53:37,081 --> 00:53:42,319
IT SEEMS LIKE A DANGEROUS PLACE
FOR A PROBE.

978
00:53:42,319 --> 00:53:46,356
IF SOMEONE WAS ON A GOOD
SPACESHIP, HOW CLOSE COULD THEY

979
00:53:46,356 --> 00:53:47,324
GET TO JUPITER?

980
00:53:47,324 --> 00:53:50,294
>> WELL, A HUMAN BEING WAS
TRYING TO SURVIVE IN JUPITER, IS

981
00:53:50,294 --> 00:53:52,729
THAT WHAT YOU'RE ASKING?

982

00:53:52,729 --> 00:53:55,566

>> YEAH.

>> NOW I REALLY DON'T KNOW.

983

00:53:55,566 --> 00:53:57,634

I WOULD SAY IT'S PRETTY HARD TO
SEND A PERSON TO JUPITER

984

00:53:57,634 --> 00:54:00,471

BECAUSE, YOU KNOW, THEY WANT A
RIDE HOME.

985

00:54:00,471 --> 00:54:06,310

IT'S HARD -- IT'S HARD TO
BRING -- YOU KNOW, A HUGE ROCKET

986

00:54:06,310 --> 00:54:07,978

TO JUPITER TO COME BACK.

987

00:54:07,978 --> 00:54:13,217

THAT'S WHY WE SEND ROBOTS
BECAUSE THEY DON'T HAVE TO COME

988

00:54:13,217 --> 00:54:13,517

HOME.

989

00:54:13,517 --> 00:54:16,186

BUT IF YOU IGNORE ALL THAT AND
SAY, HOW WELL COULD YOU SURVIVE

990

00:54:16,186 --> 00:54:16,854

I DON'T KNOW THE ANSWER.

991

00:54:16,854 --> 00:54:24,795

MY GUESS AND IT'S PURELY A GUESS
WOULD BE NOT VERY LONG.

992

00:54:24,795 --> 00:54:29,399

BUT WE'D HAVE TO GO LOOK UP THE
NUMBERS.

993

00:54:29,399 --> 00:54:29,867

WE CAN DO THAT.

994

00:54:29,867 --> 00:54:34,571

HOW MUCH RADIATION YOU GET NOT
ONLY DEPENDS ON YOUR TRAJECTORY,

995

00:54:34,571 --> 00:54:38,876

BUT HOW LONG YOU CAN SPEND
THERE.

996

00:54:38,876 --> 00:54:39,576

HOW FAST YOU CAN FLY THROUGH.

997

00:54:39,576 --> 00:54:44,448

ANOTHER REASON FOR WANTING THAT
QUICK TWO-HOUR PASS THROUGH SO

998

00:54:44,448 --> 00:54:45,916

YOU GET TO SPEND A LOT OF TIME
OUT FAR FROM THE RADIATION

999

00:54:45,916 --> 00:54:47,151

BEFORE YOU DO IT AGAIN.

1000

00:54:47,151 --> 00:54:48,318

IT DEPENDS ON SHIELDING AND HOW
MUCH ENERGY.

1001

00:54:48,318 --> 00:54:53,824

BECAUSE DIFFERENT ENERGY
PARTICLES DO DIFFERENT EFFECTS.

1002

00:54:53,824 --> 00:54:55,259

ALTHOUGH THERE'A LOT OF THINGS
THAT DAMAGE PEOPLE THAT ARE

1003

00:54:55,259 --> 00:55:00,931

PROBABLY NOT AS BAD FOR THE
SPACECRAFT.

1004

00:55:00,931 --> 00:55:03,901

SORRY I DON'T HAVE A
QUANTATIVE ANSWER.

1005

00:55:03,901 --> 00:55:07,905

>> THANK YOU.

>> ANOTHER ONE OF THESE CARDS.

1006

00:55:07,905 --> 00:55:09,873

SO THIS PERSON DOESN'T HAVE A
NAME ON IT, BUT IT SAYS WHEN

1007

00:55:09,873 --> 00:55:13,143

JUPITER IS DECOMMISSIONED AND
SENT INTO JUPITER, WHAT STUDIES

1008

00:55:13,143 --> 00:55:22,920

WILL BE STEADIED ON DESCENT?

1009

00:55:22,920 --> 00:55:24,655

THEY'RE MENTIONING SOMETHING I
DIDN'T MENTION, BUT YOU CAN FIND

1010

00:55:24,655 --> 00:55:25,222

IT ON THE WEBSITE.

1011

00:55:25,222 --> 00:55:30,327

THE MISSION IS TO CRASH IT INTO
JUPITER AND THAT'S TO PROTECT

1012

00:55:30,327 --> 00:55:30,661

EUROPA.

1013

00:55:30,661 --> 00:55:40,737

YOU'D REALLY HATE TO SPEND LOTS

OF MONEY AND 50 YEARS AND GET TO

1014

00:55:40,737 --> 00:55:42,239

EUROPA AND DIG DOWN IN THE ICE
AND FIND LIFE AND HAVE TO SAY I

1015

00:55:42,239 --> 00:55:45,609

DON'T KNOW IF IT'S EUROPA OR
CONTAMINATION FROM JUNO.

1016

00:55:45,609 --> 00:55:47,678

WE HAVE TO MAKE SURE WE DON'T DO
THAT.

1017

00:55:47,678 --> 00:55:49,546

WE'LL DESTROY IT BY CRASH IT
INTO JUPITER, UNLESS WE CAN

1018

00:55:49,546 --> 00:55:50,581

FIGURE OUT A WAY TO WIGGLE OUT
OF THAT.

1019

00:55:50,581 --> 00:56:01,391

ANDv[Hpñr SO THIS PERSON IS ASK
WHAT DO WE DO -- WHAT STUDIES

1020

00:56:01,391 --> 00:56:02,159

WILL BE DONE DURING THE DESCENT?

1021

00:56:02,159 --> 00:56:03,827

THE ANSWER -- WE HAVEN'T SETTLED
ON THAT YET.

1022

00:56:03,827 --> 00:56:08,498

BUT THE ANSWER IS PROBABLY NOT
THAT MUCH.

1023

00:56:08,498 --> 00:56:12,169

BECAUSE REMEMBER, AT THE END Ok
THAT DESCENT THE SPACECRAFT'S

1024

00:56:12,169 --> 00:56:12,469

GONE.

1025

00:56:12,469 --> 00:56:15,872

AND OUR BASIC MODEL IS TO SEND
THE DATA BACK AFTERWARDS.

1026

00:56:15,872 --> 00:56:21,445

WE DO A FLY BY AND WE SEND THE
DATA BACK.

1027

00:56:21,445 --> 00:56:24,081

SO WE'RE NOT GOING TO BE ABLE TO
SEND MUCH INFORMATION BACK AS

1028

00:56:24,081 --> 00:56:26,183

IT'S FALLING INTO JUPITER.

1029

00:56:26,183 --> 00:56:29,653

WE'LL BE LUCKY IF WE CAN
MAINTAIN CONTACT AND KEEP THE

1030

00:56:29,653 --> 00:56:33,590

SIGNAL AND TELL YOU HOW FAST IT
FELL INTO THE PLANET.

1031

00:56:33,590 --> 00:56:36,860

MAYBE WE'LL GET TO MEASURE SOME
THINGS ON THE LAST PASS AS WE

1032

00:56:36,860 --> 00:56:37,294

COME THROUGH.

1033

00:56:37,294 --> 00:56:41,665

BY THE TIME WE GET CLOSER TO
JUPITER THAN THE PREVIOUS PASSES

1034

00:56:41,665 --> 00:56:43,200

WE'LL BE OUT OF RADIO CONTACT
ANYWAY.

1035

00:56:43,200 --> 00:56:50,574

>> I HAVE TWO OR 2 1/2 QUESTIONS
ABOUT THE RADIOMETERS.

1036

00:56:50,574 --> 00:56:54,344

AT WHAT FREQUENCIES DO THE
RADIOMETERS OBSERVE AND IS EACH

1037

00:56:54,344 --> 00:57:00,917

RADIOMETER JUST OBSERVING ONE
CHANNEL AND IF OBSERVING MORE

1038

00:57:00,917 --> 00:57:03,153

THAN ONE CHANNEL HOW MANY
CHANNELS ARE THERE IN A

1039

00:57:03,153 --> 00:57:04,187

SPECTROMETER BEHIND EACH
RADIOMETER?

1040

00:57:04,187 --> 00:57:13,930

>> EACH IS IN FACT OBSERVING
JUST ONE CHANNEL.

1041

00:57:13,930 --> 00:57:15,465

AND THAT'S BECAUSE WHAT WE'RE
TRYING TO MEASURE THE ATMOSPHERE

1042

00:57:15,465 --> 00:57:19,536

OF JUB JUPITER, SO YOU DON'T
GAIN A LOT BY HAVING LOTS OF

1043

00:57:19,536 --> 00:57:20,671

CHANNELS AND YOU LOSE THE SIGNAL
TO NOISE.

1044

00:57:20,671 --> 00:57:28,712

IT'S HARDER TO MEASURE WITH
PRECISION A LOT OF CHANNELS THAN

1045

00:57:28,712 --> 00:57:29,880

IT IS TO MEASURE ONE BIG WIDE
CHANNEL.

1046

00:57:29,880 --> 00:57:34,184

SO THERE ARE SIX DIFFERENT
RADIOMETERS.

1047

00:57:34,184 --> 00:57:36,620

EACH A DIFFERENT FREQUENCY.

1048

00:57:36,620 --> 00:57:44,194

THE LONGEST S 600 MEGAHERTZ AND
THEN DOUBLE IT AGAIN, DOUBLE IT

1049

00:57:44,194 --> 00:57:45,462

AGAIN, SO FORTH.

1050

00:57:45,462 --> 00:57:48,298

IT'S NOT EXACTLY DOUBLING EVERY
TIME, BUT PRETTY CLOSE TO

1051

00:57:48,298 --> 00:57:53,303

DOUBLING FROM THE 600 MEGAHERTZ
UP TO 20 GIGAHERTZ OR SO.

1052

00:57:53,303 --> 00:57:54,137

>> YOU SAID 20?

1053

00:57:54,137 --> 00:57:57,574

>> YEAH.

>> THE REASON YOU DON'T HAVE

1054

00:57:57,574 --> 00:58:01,044

SEVERAL CHANNELS OF EACH
RADIOMETRY IS BECAUSE THEY'RE SO

1055

00:58:01,044 --> 00:58:03,947

PRESSURE BROADENED, NO SENSE IN TRYING TO RESOLVE THEM?

1056

00:58:03,947 --> 00:58:09,820

>> YEAH, I WON'T SAY THERE'S NO SENSE IN TRYING TO RESOLVE THEM.

1057

00:58:09,820 --> 00:58:12,255

I'M SURE THAT SOMEBODY WOULD SAY THERE HERE'S GREAT SCIENCE YOU

1058

00:58:12,255 --> 00:58:16,927

COULD DO WITH A RADIOMETER, BUT IF YOU'RE GOING AFTER THE WATER

1059

00:58:16,927 --> 00:58:20,397

CONTENT HAVING A LOT OF CHANNELS BEHIND EACH OF THESE ISN'T GOING

1060

00:58:20,397 --> 00:58:23,300

TO HURT THAT MUCH AND IS GOING TO SIGNAL IN THE NOISE.

1061

00:58:23,300 --> 00:58:25,535

>> HELLO.

1062

00:58:25,535 --> 00:58:45,822

WILL JUNO BE ABLE TO MEASURE THE -- H SHALL I SAY THE

1063

00:58:45,822 --> 00:58:48,125

INFERMETER AROUND THE EQUATOR?

1064

00:58:48,125 --> 00:58:51,628

>> I DON'T KNOW IF I UNDERSTAND 100% WHAT YOU'RE ASKING.

1065

00:58:51,628 --> 00:58:55,365

ARE YOU ASKING IF WE'LL MEASURE
THE RADIATION AROUND THE --

1066

00:58:55,365 --> 00:58:55,999

>> NO, I SHOULD QUALIFY.

1067

00:58:55,999 --> 00:58:57,167

I WAS TALKING ABOUT CONVECTION.

>> OH, OKAY.

1068

00:58:57,167 --> 00:59:03,140

SO WE WILL LEARN A LOT ABOUT THE
MOTION IN THE ATMOSPHERE AROUND

1069

00:59:03,140 --> 00:59:08,111

THE EQUATOR OF JUPITER AND
ELSEWHERE ON JUPITER.

1070

00:59:08,111 --> 00:59:14,518

TWO BIG WAYS TO DO THAT.

1071

00:59:14,518 --> 00:59:16,286

ONE IS THE GRAVITY EXPERIMENT IS
GOING TO TELL YOU WHEN SEE THE

1072

00:59:16,286 --> 00:59:19,356

BIG STRUCTURES IT WILL TELL YOU
HOW DEEP THEY ARE BASED ON THE

1073

00:59:19,356 --> 00:59:20,857

MOTION OF THE STRUCTURE, THE
GRAVITATIONAL SIGNATURE FROM IT.

1074

00:59:20,857 --> 00:59:28,331

SO IF IT'S MOVING AND IT'S DEEP,
YOU'LL HAVE A DIFFERENT

1075

00:59:28,331 --> 00:59:30,834

SIGNATURE THAN IF IT'S MOVING
AND IT'S SHALLOW.

1076

00:59:30,834 --> 00:59:34,571

THE MICROWAVE RECEIVERS BECAUSE
THEY'RE SEEING SIX DIFFERENT

1077

00:59:34,571 --> 00:59:40,410

DEPTHS AND BECAUSE THEY'RE
SEEING A WHOLE RANGE OF ANGLES

1078

00:59:40,410 --> 00:59:43,313

THEY'LL TELL US SOMETHING ABOUT
THE STRUCTURE.

1079

00:59:43,313 --> 00:59:49,553

HOW MUCH WE'LL LEARN WE HAVE TO
FIND OUT WHEN WE GET THERE.

1080

00:59:49,553 --> 00:59:51,021

I SUSPECT AND YOU KNOW EVERY
INSTRUMENT HAS ITS OWN -- EVERY

1081

00:59:51,021 --> 00:59:52,756

EXPERIMENT HAS ITS OWN THING TO
WORRY ABOUT.

1082

00:59:52,756 --> 01:00:03,333

FOR THE MICROWAVE RECEIVER I
SUSPECT THE BIGGEST THING TO

1083

01:00:03,333 --> 01:00:07,571

WORRY ABOUT IS THE JUPITER WILL
SURPRISE US SOMEHOW IN HOW THE

1084

01:00:07,571 --> 01:00:09,039

ATMOSPHERE BEHAVES AND HOW THE
TEMPERATURE DEPENDENCE BEHAVES.

1085

01:00:09,039 --> 01:00:10,507

WE'LL GET THE MEASUREMENT AND
THEN WE HAVE TO PUZZLE IT OUT TO

1086

01:00:10,507 --> 01:00:11,141

FIGURE OUT WHAT IT MEANS.

1087

01:00:11,141 --> 01:00:14,411

WE'RE NOT THERE YET, BUT MAYBE
THE MODELS WE HAVE WILL BE

1088

01:00:14,411 --> 01:00:14,778

PERFECT.

1089

01:00:14,778 --> 01:00:17,781

BUT MY PREDICTION WE'LL GET A
GREAT MEASUREMENT AND THEN

1090

01:00:17,781 --> 01:00:21,184

FIGURE OUT WHAT IT MEANS BUT
PROBABLY NOT THE FIRST COUPLE OF

1091

01:00:21,184 --> 01:00:24,254

DAYS.

>> I HAD WONDERED IF THE

1092

01:00:24,254 --> 01:00:26,256

MEASUREMENTS WERE DIFFERENT IN
REGARD TO THE ZONES AROUND THE

1093

01:00:26,256 --> 01:00:27,290

EQUATOR.

>> THE MEASUREMENTS AREN'T

1094

01:00:27,290 --> 01:00:30,861

BECAUSE THE RADIOMETER JUST
MEASURES EVERYTHING IT GETS AND

1095

01:00:30,861 --> 01:00:37,801

THE GRAVITATIONAL THING YOU JUST
MEASURE THE SIGNATURE YOU'RE

1096

01:00:37,801 --> 01:00:38,168
GETTING.

1097
01:00:38,168 --> 01:00:40,136
BUT HOW TO INTERPRET THEM IS
DIFFERENT.

1098
01:00:40,136 --> 01:00:46,243
AS YOU'RE DOWN NEAR THE EQUATOR,
THINGS ARE NARROWER.

1099
01:00:46,243 --> 01:00:48,645
AND THE DYNAMICS GOING AROUND
THE PLANET LONGITUDE NATURALLY

1100
01:00:48,645 --> 01:00:50,080
ARE DIFFERENT, YOU WANT TO
INTERPRET THE MEASUREMENTS IN A

1101
01:00:50,080 --> 01:00:50,947
DIFFERENT WAY.
>> THANK YOU.