



THE OUTER PLANETS:
HUBBLE'S CONTINUING LEGACY



1
00:00:06,230 --> 00:00:03,990
to observe with hubble we actually have

2
00:00:08,310 --> 00:00:06,240
to plan out pretty far in advance and

3
00:00:10,390 --> 00:00:08,320
for the outer planets what we do is we

4
00:00:12,390 --> 00:00:10,400
pick the time when they're at opposition

5
00:00:14,150 --> 00:00:12,400
and that means that it's opposite from

6
00:00:15,669 --> 00:00:14,160
the sun from the earth's point of view

7
00:00:17,670 --> 00:00:15,679
and that basically gives us the highest

8
00:00:19,429 --> 00:00:17,680
resolution view that's when hubble is

9
00:00:21,670 --> 00:00:19,439
the closest to each planet even though

10
00:00:22,790 --> 00:00:21,680
that doesn't vary much over a year and

11
00:00:25,109 --> 00:00:22,800
the planets are a little bit more

12
00:00:27,349 --> 00:00:25,119
challenging because they move and so

13
00:00:28,790 --> 00:00:27,359

hubble has to find guide stars first

14

00:00:30,790 --> 00:00:28,800

that tell it where it's pointing in the

15

00:00:32,630 --> 00:00:30,800

sky but then it has to track those

16

00:00:34,630 --> 00:00:32,640

planets so it has to move following the

17

00:00:36,229 --> 00:00:34,640

planet across the sky and so that has to

18

00:00:37,830 --> 00:00:36,239

be interleaved with all the other

19

00:00:39,750 --> 00:00:37,840

science program hubble's doing every

20

00:00:41,750 --> 00:00:39,760

single day and so it's very carefully

21

00:00:43,590 --> 00:00:41,760

coordinated to fit in as hubble then

22

00:00:45,190 --> 00:00:43,600

orbits around the earth and so it gets

23

00:00:47,670 --> 00:00:45,200

planned out down to the minutes of

24

00:00:49,510 --> 00:00:47,680

exactly which image we're going to take

25

00:00:52,790 --> 00:00:49,520

in which filter for each of those

26
00:00:56,709 --> 00:00:54,950
so it's a cosmic dance of getting hubble

27
00:00:58,549 --> 00:00:56,719
pointed in the right place moving in the

28
00:01:01,610 --> 00:00:58,559
right direction and tracking all at the

29
00:01:06,230 --> 00:01:03,590
[Applause]

30
00:01:08,630 --> 00:01:06,240
the opal project or the outer planet's

31
00:01:10,469 --> 00:01:08,640
atmosphere's legacy program is an

32
00:01:12,950 --> 00:01:10,479
observational program using the hubble

33
00:01:14,310 --> 00:01:12,960
space telescope and what we're doing is

34
00:01:16,390 --> 00:01:14,320
we're looking at each of the outer

35
00:01:18,550 --> 00:01:16,400
planets every year so that we can build

36
00:01:20,390 --> 00:01:18,560
up a time base using the exact same

37
00:01:22,390 --> 00:01:20,400
facility and the same instruments so we

38
00:01:30,789 --> 00:01:22,400

can actually track what's changing over

39

00:01:35,670 --> 00:01:34,230

it started really with jupiter

40

00:01:37,670 --> 00:01:35,680

in essence we were trying to look at the

41

00:01:38,950 --> 00:01:37,680

weather on jupiter

42

00:01:40,789 --> 00:01:38,960

and as we're trying to understand

43

00:01:42,630 --> 00:01:40,799

whether we know even here on earth it

44

00:01:43,590 --> 00:01:42,640

changes every minute every hour every

45

00:01:44,950 --> 00:01:43,600

day

46

00:01:46,789 --> 00:01:44,960

and we didn't have that kind of time

47

00:01:48,550 --> 00:01:46,799

coverage but we also didn't even have

48

00:01:50,469 --> 00:01:48,560

long time coverage to look at things

49

00:01:52,149 --> 00:01:50,479

that changed over seasons and so we had

50

00:01:53,749 --> 00:01:52,159

this big gap in our knowledge where we

51
00:01:55,670 --> 00:01:53,759
just weren't getting frequent enough

52
00:01:58,630 --> 00:01:55,680
data to be able to trend any of these

53
00:02:00,870 --> 00:01:58,640
things and the idea kind of came about

54
00:02:03,510 --> 00:02:00,880
to look at a legacy program where we

55
00:02:05,990 --> 00:02:03,520
built up a legacy for hubble within the

56
00:02:07,510 --> 00:02:06,000
planetary community and in 2014 we

57
00:02:08,790 --> 00:02:07,520
started with our first observations of

58
00:02:10,710 --> 00:02:08,800
uranus

59
00:02:12,949 --> 00:02:10,720
and the first thing i think we noticed

60
00:02:15,270 --> 00:02:12,959
was uranus had a very prominent polar

61
00:02:17,270 --> 00:02:15,280
cap it was very much brighter and

62
00:02:18,470 --> 00:02:17,280
getting brighter over time we've watched

63
00:02:19,670 --> 00:02:18,480

it over the last few years get much

64

00:02:21,350 --> 00:02:19,680

brighter

65

00:02:23,190 --> 00:02:21,360

neptune on the other hand has been

66

00:02:24,869 --> 00:02:23,200

really quite interesting the first thing

67

00:02:26,550 --> 00:02:24,879

we noted was it had a lot of bright

68

00:02:28,229 --> 00:02:26,560

white clouds and they were coming and

69

00:02:29,300 --> 00:02:28,239

going pretty rapidly at a lot of

70

00:02:31,910 --> 00:02:29,310

different latitudes

71

00:02:34,229 --> 00:02:31,920

[Music]

72

00:02:36,390 --> 00:02:34,239

and so when we start looking at neptune

73

00:02:38,390 --> 00:02:36,400

and uranus as dynamic planets with

74

00:02:40,550 --> 00:02:38,400

changing atmospheres weather like we

75

00:02:42,150 --> 00:02:40,560

know now for jupiter and saturn

76

00:02:46,710 --> 00:02:42,160

we realize that we have a lot of gaps in

77

00:02:50,869 --> 00:02:48,869

and so we've been able to use the opel

78

00:02:52,550 --> 00:02:50,879

program to track how much cloud cover we

79

00:02:53,830 --> 00:02:52,560

have from year to year but the other

80

00:02:55,750 --> 00:02:53,840

thing we can do with hubble that we

81

00:02:57,190 --> 00:02:55,760

can't really do any other way is look

82

00:02:59,830 --> 00:02:57,200

for dark spots

83

00:03:01,910 --> 00:02:59,840

and so the great dark spot was this big

84

00:03:03,670 --> 00:03:01,920

iconic feature we saw with voyager and

85

00:03:05,190 --> 00:03:03,680

when we looked again a few years later

86

00:03:06,949 --> 00:03:05,200

finally when hubble was online it was

87

00:03:08,869 --> 00:03:06,959

gone

88

00:03:10,550 --> 00:03:08,879

and that kind of surprised us because we

89

00:03:12,869 --> 00:03:10,560

were used to the great red spot which

90

00:03:14,230 --> 00:03:12,879

doesn't go away it's changed over time

91

00:03:15,830 --> 00:03:14,240

but it's still there

92

00:03:17,430 --> 00:03:15,840

[Music]

93

00:03:19,110 --> 00:03:17,440

and so these storms are not quite the

94

00:03:21,190 --> 00:03:19,120

same as what we see on jupiter because

95

00:03:23,750 --> 00:03:21,200

they form and go away on much more rapid

96

00:03:25,509 --> 00:03:23,760

time scales

97

00:03:27,589 --> 00:03:25,519

the latest image of neptune is really

98

00:03:29,030 --> 00:03:27,599

interesting to me because we don't see

99

00:03:30,789 --> 00:03:29,040

those bright weight clouds we've been

100

00:03:32,390 --> 00:03:30,799

seeing the last few years as a matter of

101
00:03:34,630 --> 00:03:32,400
fact the only thing we see in that

102
00:03:36,710 --> 00:03:34,640
particular image is this great dark spot

103
00:03:38,630 --> 00:03:36,720
and so in a lot of ways it brings us

104
00:03:41,430 --> 00:03:38,640
around full circle because this looks so

105
00:03:43,670 --> 00:03:41,440
much like the voyager image from 1989

106
00:03:45,350 --> 00:03:43,680
and that was pretty surprising to me not

107
00:03:48,470 --> 00:03:45,360
to see as much cloud activity as we've

108
00:03:50,149 --> 00:03:48,480
been seeing in previous years

109
00:03:52,550 --> 00:03:50,159
the opal team's actually a fairly small

110
00:03:54,149 --> 00:03:52,560
team there's only three of us but our

111
00:03:55,589 --> 00:03:54,159
data is immediately available to the

112
00:03:57,910 --> 00:03:55,599
public and any other scientist that

113
00:04:01,110 --> 00:03:57,920

wants to use them and so we do that as

114

00:04:03,270 --> 00:04:01,120

well as our own scientific analysis

115

00:04:05,270 --> 00:04:03,280

i think having so much hubble data now

116

00:04:06,949 --> 00:04:05,280

there's just so much in there to study

117

00:04:09,030 --> 00:04:06,959

and you know as a scientist that's what

118

00:04:11,270 --> 00:04:09,040

drives us is trying to solve mysteries

119

00:04:13,509 --> 00:04:11,280

trying to look for new mysteries and so

120

00:04:15,429 --> 00:04:13,519

having these long-term data sets with

121

00:04:17,030 --> 00:04:15,439

just such rich numbers of features in

122

00:04:18,789 --> 00:04:17,040

there there's always something to go

123

00:04:20,469 --> 00:04:18,799

look at and it's certainly going to keep

124

00:04:24,310 --> 00:04:20,479

us busy for years to come even when