



INFRARED

**BEYOND
THE VISIBLE**

**The Science Behind
the James Webb
Space Telescope**

1
00:00:06,980 --> 00:00:04,190
humanity has always been drawn to the

2
00:00:10,789 --> 00:00:06,990
night sky we draw pictures in the Stars

3
00:00:13,940 --> 00:00:10,799
track the planets see signs importance

4
00:00:15,890 --> 00:00:13,950
and celestial objects but so much of the

5
00:00:18,710 --> 00:00:15,900
universe is beyond our reach

6
00:00:20,390 --> 00:00:18,720
vast distances separate us from the

7
00:00:23,890 --> 00:00:20,400
sites that might answer some of our

8
00:00:28,400 --> 00:00:23,900
biggest questions how do galaxies form

9
00:00:30,350 --> 00:00:28,410
how do stars and planets come to be do

10
00:00:33,710 --> 00:00:30,360
distant planets have the conditions

11
00:00:35,510 --> 00:00:33,720
necessary for life to construct and test

12
00:00:38,630 --> 00:00:35,520
our theories we need to see what's

13
00:00:42,160 --> 00:00:38,640

happening so we build tools to extend

14

00:00:46,850 --> 00:00:42,170

our vision they get bigger more powerful

15

00:00:48,740 --> 00:00:46,860

more advanced as time goes on astronomy

16

00:00:56,490 --> 00:00:48,750

stops relying on the light we can see

17

00:01:01,799 --> 00:00:58,979

when you look at the world here seeing

18

00:01:03,720 --> 00:01:01,809

something we call visible light but

19

00:01:06,930 --> 00:01:03,730

visible light is really only a certain

20

00:01:09,600 --> 00:01:06,940

form of radiation our universe is full

21

00:01:13,410 --> 00:01:09,610

of many different types of radiation it

22

00:01:16,139 --> 00:01:13,420

surrounds us our bodies evolved to

23

00:01:18,480 --> 00:01:16,149

detect visible light with our eyes but

24

00:01:21,060 --> 00:01:18,490

they also evolved to detect another kind

25

00:01:24,990 --> 00:01:21,070

of radiation called infrared light our

26

00:01:27,600 --> 00:01:25,000

bodies feel infrared light is heat this

27

00:01:30,320 --> 00:01:27,610

infrared radiation was discovered by the

28

00:01:32,940 --> 00:01:30,330

astronomer Frederick William Herschel

29

00:01:35,880 --> 00:01:32,950

Herschel knew that a prism could be used

30

00:01:37,950 --> 00:01:35,890

to break white light into colors he

31

00:01:41,639 --> 00:01:37,960

wanted to know whether the colors had

32

00:01:43,740 --> 00:01:41,649

different temperatures they did but then

33

00:01:45,930 --> 00:01:43,750

Herschel measured the empty space just

34

00:01:49,800 --> 00:01:45,940

beyond the red light though no sunlight

35

00:01:53,539 --> 00:01:49,810

was visible it was hot Herschel had just

36

00:01:55,830 --> 00:01:53,549

discovered invisible infrared radiation

37

00:01:58,620 --> 00:01:55,840

humanity now knew that there were forms

38

00:02:02,040 --> 00:01:58,630

of radiation that could not be seen they

39
00:02:03,839 --> 00:02:02,050
could be anywhere all around us how many

40
00:02:07,589 --> 00:02:03,849
were there what were they up to

41
00:02:10,919 --> 00:02:07,599
what were they hiding obviously we had

42
00:02:12,809 --> 00:02:10,929
to find out a type of energy that

43
00:02:15,360 --> 00:02:12,819
travels through the universe in the form

44
00:02:18,330 --> 00:02:15,370
of waves is called electromagnetic

45
00:02:20,309 --> 00:02:18,340
radiation the entire range of it from

46
00:02:22,350 --> 00:02:20,319
high-energy gamma rays to low energy

47
00:02:25,030 --> 00:02:22,360
radio waves is called the

48
00:02:27,140 --> 00:02:25,040
electromagnetic spectrum

49
00:02:31,309 --> 00:02:28,910
although our eyes can see only visible

50
00:02:33,979 --> 00:02:31,319
light we can build tools like infrared

51
00:02:37,250 --> 00:02:33,989
detecting cameras to see other forms of

52
00:02:40,390 --> 00:02:37,260
radiation these tools are man-made eyes

53
00:02:44,449 --> 00:02:40,400
that view invisible radiation for us and

54
00:02:47,059 --> 00:02:44,459
transform it into pictures

55
00:02:49,880 --> 00:02:47,069
objects can emit all kinds of radiation

56
00:02:52,459 --> 00:02:49,890
huh observing the entirety of that

57
00:02:58,039 --> 00:02:52,469
radiation gives us a true picture of an

58
00:03:01,610 --> 00:02:58,049
object when we turn these tools on space

59
00:03:05,209 --> 00:03:01,620
they open up the entire cosmos to us in

60
00:03:08,809 --> 00:03:05,219
its full glory when we look at the night

61
00:03:11,110 --> 00:03:08,819
sky we see stars and planets galaxies

62
00:03:13,699 --> 00:03:11,120
and nebulae in the form of visible light

63
00:03:18,500 --> 00:03:13,709

but if we could see in infrared light

64

00:03:20,240 --> 00:03:18,510

the sky would appear very different for

65

00:03:23,059 --> 00:03:20,250

one thing infrared lights long

66

00:03:24,890 --> 00:03:23,069

wavelengths penetrate clouds of gas and

67

00:03:27,080 --> 00:03:24,900

dust

68

00:03:29,300 --> 00:03:27,090

the shorter wavelengths of visible light

69

00:03:32,300 --> 00:03:29,310

are stopped and scattered as they fight

70

00:03:34,250 --> 00:03:32,310

through collections of particles so by

71

00:03:37,460 --> 00:03:34,260

detecting infrared light we can see

72

00:03:41,020 --> 00:03:37,470

through clouds of gas and dust to warm

73

00:03:43,699 --> 00:03:41,030

objects inside like just forming stars

74

00:03:45,979 --> 00:03:43,709

the objects that don't glow with any

75

00:03:48,080 --> 00:03:45,989

visible light of their own like planets

76

00:03:51,500 --> 00:03:48,090

are still often warm enough to radiate

77

00:03:54,080 --> 00:03:51,510

infrared light perhaps allowing us to

78

00:03:56,839 --> 00:03:54,090

glimpse them and by observing how

79

00:03:59,750 --> 00:03:56,849

infrared light from a planet star passes

80

00:04:02,630 --> 00:03:59,760

through its atmosphere we acquire clues

81

00:04:04,759 --> 00:04:02,640

about the planets composition the dust

82

00:04:08,030 --> 00:04:04,769

left behind by distant planets as they

83

00:04:11,360 --> 00:04:08,040

form will also glow in infrared helping

84

00:04:13,759 --> 00:04:11,370

to show us how planets are born so

85

00:04:16,279 --> 00:04:13,769

infrared helps us see objects like these

86

00:04:18,830 --> 00:04:16,289

in our own galactic backyard but it can

87

00:04:20,990 --> 00:04:18,840

also help us observe the first objects

88

00:04:22,330 --> 00:04:21,000

that formed in the universe after the

89

00:04:24,500 --> 00:04:22,340

Big Bang

90

00:04:26,689 --> 00:04:24,510

imagine you gave a letter to the post

91

00:04:28,760 --> 00:04:26,699

office and they galaxies billions of

92

00:04:31,700 --> 00:04:28,770

light years away and addressed it to

93

00:04:34,640 --> 00:04:31,710

earth it would travel for an incredibly

94

00:04:36,980 --> 00:04:34,650

long time when it finally arrived at its

95

00:04:39,260 --> 00:04:36,990

destination the person who opened it

96

00:04:42,050 --> 00:04:39,270

would be getting news from billions of

97

00:04:44,000 --> 00:04:42,060

years earlier the light from the first

98

00:04:45,200 --> 00:04:44,010

stars to shine in the universe is

99

00:04:48,680 --> 00:04:45,210

something like that

100

00:04:51,200 --> 00:04:48,690

it left the stars ages ago and is still

101

00:04:54,320 --> 00:04:51,210

out there in space traveling the vast

102

00:04:57,080 --> 00:04:54,330

distances between galaxies if we could

103

00:04:59,320 --> 00:04:57,090

see it we could see those galaxies as

104

00:05:02,510 --> 00:04:59,330

they were in the early universe

105

00:05:05,629 --> 00:05:02,520

essentially we would be seeing back in

106

00:05:10,370 --> 00:05:05,639

time but we haven't been able to see it

107

00:05:12,500 --> 00:05:10,380

why because the universe is expanding as

108

00:05:15,650 --> 00:05:12,510

light travels across space it's

109

00:05:18,680 --> 00:05:15,660

stretched like taffy by the expansion

110

00:05:21,409 --> 00:05:18,690

the first stars gave off mostly visible

111

00:05:24,129 --> 00:05:21,419

and ultraviolet light but the stretching

112

00:05:28,370 --> 00:05:24,139

changes those waves into infrared light

113

00:05:30,500 --> 00:05:28,380

this is called red shifting the only way

114

00:05:32,930 --> 00:05:30,510

to see that light as it arrives in our

115

00:05:33,310 --> 00:05:32,940

region of the universe is to look for

116

00:05:37,300 --> 00:05:33,320

that

117

00:05:39,790 --> 00:05:37,310

faint infrared glow by capturing it we

118

00:05:42,270 --> 00:05:39,800

will be able to create images of the

119

00:05:44,920 --> 00:05:42,280

first galaxies to form in the universe

120

00:05:47,260 --> 00:05:44,930

by witnessing the birth of the first

121

00:05:49,180 --> 00:05:47,270

stars and galaxies we deepen our

122

00:05:52,270 --> 00:05:49,190

knowledge of how the universe as we know

123

00:05:55,000 --> 00:05:52,280

it came to be how did we get from those

124

00:05:58,540 --> 00:05:55,010

first blazing stars to the islands of

125

00:06:00,730 --> 00:05:58,550

billions of stars we see today what will

126
00:06:02,370 --> 00:06:00,740
we learn about how galaxies grow and

127
00:06:05,210 --> 00:06:02,380
evolve

128
00:06:09,900 --> 00:06:05,220
how did the chaos of the early universe

129
00:06:12,210 --> 00:06:09,910
transform into order and structure NASA

130
00:06:15,810 --> 00:06:12,220
is currently building the James Webb

131
00:06:18,300 --> 00:06:15,820
Space Telescope with its huge infrared

132
00:06:20,970 --> 00:06:18,310
capturing mirror and distant orbit far

133
00:06:23,820 --> 00:06:20,980
beyond the moon Webb will allow us to

134
00:06:27,720 --> 00:06:23,830
view the cosmos as we've never seen it

135
00:06:29,850 --> 00:06:27,730
before Webb will search for signs of

136
00:06:34,200 --> 00:06:29,860
water vapor on planets around other

137
00:06:38,730 --> 00:06:34,210
stars it will take pictures of the

138
00:06:41,580 --> 00:06:38,740

universes infancy Webb will reveal the

139

00:06:45,960 --> 00:06:41,590

hidden stars and solar systems forming

140

00:06:48,390 --> 00:06:45,970

within cocoons of dust the answers to

141

00:06:50,640 --> 00:06:48,400

some of the universe's biggest mysteries

142

00:06:53,670 --> 00:06:50,650

and more questions we haven't thought to

143

00:06:58,080 --> 00:06:53,680

ask are waiting out there for us in the

144

00:07:00,520 --> 00:06:58,090

form of infrared radiation all we have

145

00:07:17,940 --> 00:07:00,530

to do is look