

1  
00:00:01,520 --> 00:00:06,990  
humanity has always been drawn to the

2  
00:00:04,200 --> 00:00:10,798  
night sky we draw pictures in the Stars

3  
00:00:06,990 --> 00:00:13,949  
track the planets see signs importance

4  
00:00:10,798 --> 00:00:15,899  
and celestial objects but so much of the

5  
00:00:13,949 --> 00:00:18,719  
universe is beyond our reach

6  
00:00:15,900 --> 00:00:20,399  
vast distances separate us from the

7  
00:00:18,719 --> 00:00:23,899  
sites that might answer some of our

8  
00:00:20,399 --> 00:00:28,409  
biggest questions how do galaxies form

9  
00:00:23,899 --> 00:00:30,359  
how do stars and planets come to be do

10  
00:00:28,410 --> 00:00:33,719  
distant planets have the conditions

11  
00:00:30,359 --> 00:00:35,519  
necessary for life to construct and test

12  
00:00:33,719 --> 00:00:38,640  
our theories we need to see what's

13  
00:00:35,520 --> 00:00:42,170  
happening so we build tools to extend

14  
00:00:38,640 --> 00:00:46,859  
our vision they get bigger more powerful

15  
00:00:42,170 --> 00:00:48,750  
more advanced as time goes on astronomy

16  
00:00:46,859 --> 00:00:52,250  
stops relying on the light we can see

17  
00:00:48,750 --> 00:00:52,250  
only with our eyes

18  
00:00:56,500 --> 00:01:01,808  
when you look at the world here seeing

19  
00:00:58,988 --> 00:01:03,729  
something we call visible light but

20  
00:01:01,808 --> 00:01:06,939  
visible light is really only a certain

21  
00:01:03,729 --> 00:01:09,609  
form of radiation our universe is full

22  
00:01:06,939 --> 00:01:13,420  
of many different types of radiation it

23  
00:01:09,609 --> 00:01:16,149  
surrounds us our bodies evolved to

24  
00:01:13,420 --> 00:01:18,490  
detect visible light with our eyes but

25  
00:01:16,149 --> 00:01:21,070  
they also evolved to detect another kind

26  
00:01:18,489 --> 00:01:25,000  
of radiation called infrared light our

27  
00:01:21,069 --> 00:01:27,609  
bodies feel infrared light is heat this

28  
00:01:25,000 --> 00:01:30,329  
infrared radiation was discovered by the

29

00:01:27,609 --> 00:01:32,950  
astronomer Frederick William Herschel

30  
00:01:30,329 --> 00:01:35,890  
Herschel knew that a prism could be used

31  
00:01:32,950 --> 00:01:37,960  
to break white light into colors he

32  
00:01:35,890 --> 00:01:41,649  
wanted to know whether the colors had

33  
00:01:37,959 --> 00:01:43,750  
different temperatures they did but then

34  
00:01:41,649 --> 00:01:45,939  
Herschel measured the empty space just

35  
00:01:43,750 --> 00:01:49,810  
beyond the red light though no sunlight

36  
00:01:45,939 --> 00:01:53,548  
was visible it was hot Herschel had just

37  
00:01:49,810 --> 00:01:55,840  
discovered invisible infrared radiation

38  
00:01:53,549 --> 00:01:58,630  
humanity now knew that there were forms

39  
00:01:55,840 --> 00:02:02,049  
of radiation that could not be seen they

40  
00:01:58,629 --> 00:02:03,848  
could be anywhere all around us how many

41  
00:02:02,049 --> 00:02:07,599  
were there what were they up to

42  
00:02:03,849 --> 00:02:10,929  
what were they hiding obviously we had

43  
00:02:07,599 --> 00:02:12,819

to find out a type of energy that

44

00:02:10,929 --> 00:02:15,370

travels through the universe in the form

45

00:02:12,818 --> 00:02:18,339

of waves is called electromagnetic

46

00:02:15,370 --> 00:02:20,319

radiation the entire range of it from

47

00:02:18,340 --> 00:02:22,360

high-energy gamma rays to low energy

48

00:02:20,318 --> 00:02:25,039

radio waves is called the

49

00:02:22,360 --> 00:02:27,099

electromagnetic spectrum

50

00:02:25,039 --> 00:02:27,098

you

51

00:02:27,150 --> 00:02:31,319

although our eyes can see only visible

52

00:02:28,919 --> 00:02:33,988

light we can build tools like infrared

53

00:02:31,318 --> 00:02:37,259

detecting cameras to see other forms of

54

00:02:33,989 --> 00:02:40,400

radiation these tools are man-made eyes

55

00:02:37,259 --> 00:02:44,459

that view invisible radiation for us and

56

00:02:40,400 --> 00:02:47,069

transform it into pictures

57

00:02:44,459 --> 00:02:49,890

objects can emit all kinds of radiation

58  
00:02:47,068 --> 00:02:52,468  
huh observing the entirety of that

59  
00:02:49,889 --> 00:02:58,048  
radiation gives us a true picture of an

60  
00:02:52,468 --> 00:03:01,620  
object when we turn these tools on space

61  
00:02:58,049 --> 00:03:05,218  
they open up the entire cosmos to us in

62  
00:03:01,620 --> 00:03:08,819  
its full glory when we look at the night

63  
00:03:05,218 --> 00:03:11,120  
sky we see stars and planets galaxies

64  
00:03:08,818 --> 00:03:13,708  
and nebulae in the form of visible light

65  
00:03:11,120 --> 00:03:18,509  
but if we could see in infrared light

66  
00:03:13,709 --> 00:03:20,250  
the sky would appear very different for

67  
00:03:18,509 --> 00:03:23,068  
one thing infrared lights long

68  
00:03:20,250 --> 00:03:24,900  
wavelengths penetrate clouds of gas and

69  
00:03:23,068 --> 00:03:27,089  
dust

70  
00:03:24,900 --> 00:03:29,310  
the shorter wavelengths of visible light

71  
00:03:27,090 --> 00:03:32,310  
are stopped and scattered as they fight

72  
00:03:29,310 --> 00:03:34,259  
through collections of particles so by

73  
00:03:32,310 --> 00:03:37,469  
detecting infrared light we can see

74  
00:03:34,259 --> 00:03:41,030  
through clouds of gas and dust to warm

75  
00:03:37,469 --> 00:03:43,709  
objects inside like just forming stars

76  
00:03:41,030 --> 00:03:45,989  
the objects that don't glow with any

77  
00:03:43,709 --> 00:03:48,090  
visible light of their own like planets

78  
00:03:45,989 --> 00:03:51,509  
are still often warm enough to radiate

79  
00:03:48,090 --> 00:03:54,090  
infrared light perhaps allowing us to

80  
00:03:51,509 --> 00:03:56,848  
glimpse them and by observing how

81  
00:03:54,090 --> 00:03:59,759  
infrared light from a planet star passes

82  
00:03:56,848 --> 00:04:02,639  
through its atmosphere we acquire clues

83  
00:03:59,759 --> 00:04:04,769  
about the planets composition the dust

84  
00:04:02,639 --> 00:04:08,039  
left behind by distant planets as they

85  
00:04:04,769 --> 00:04:11,370  
form will also glow in infrared helping

86

00:04:08,039 --> 00:04:13,769  
to show us how planets are born so

87  
00:04:11,370 --> 00:04:16,288  
infrared helps us see objects like these

88  
00:04:13,769 --> 00:04:18,840  
in our own galactic backyard but it can

89  
00:04:16,288 --> 00:04:21,000  
also help us observe the first objects

90  
00:04:18,839 --> 00:04:22,339  
that formed in the universe after the

91  
00:04:21,000 --> 00:04:24,509  
Big Bang

92  
00:04:22,339 --> 00:04:26,698  
imagine you gave a letter to the post

93  
00:04:24,509 --> 00:04:28,769  
office and they galaxies billions of

94  
00:04:26,699 --> 00:04:31,710  
light years away and addressed it to

95  
00:04:28,769 --> 00:04:34,649  
earth it would travel for an incredibly

96  
00:04:31,709 --> 00:04:36,989  
long time when it finally arrived at its

97  
00:04:34,649 --> 00:04:39,269  
destination the person who opened it

98  
00:04:36,990 --> 00:04:42,060  
would be getting news from billions of

99  
00:04:39,269 --> 00:04:44,009  
years earlier the light from the first

100  
00:04:42,060 --> 00:04:45,209

stars to shine in the universe is

101

00:04:44,009 --> 00:04:48,689  
something like that

102

00:04:45,209 --> 00:04:51,209  
it left the stars ages ago and is still

103

00:04:48,689 --> 00:04:54,329  
out there in space traveling the vast

104

00:04:51,209 --> 00:04:57,089  
distances between galaxies if we could

105

00:04:54,329 --> 00:04:59,329  
see it we could see those galaxies as

106

00:04:57,089 --> 00:05:02,519  
they were in the early universe

107

00:04:59,329 --> 00:05:05,639  
essentially we would be seeing back in

108

00:05:02,519 --> 00:05:10,379  
time but we haven't been able to see it

109

00:05:05,639 --> 00:05:12,509  
why because the universe is expanding as

110

00:05:10,379 --> 00:05:15,659  
light travels across space it's

111

00:05:12,509 --> 00:05:18,689  
stretched like taffy by the expansion

112

00:05:15,660 --> 00:05:21,419  
the first stars gave off mostly visible

113

00:05:18,689 --> 00:05:24,139  
and ultraviolet light but the stretching

114

00:05:21,418 --> 00:05:28,379  
changes those waves into infrared light



115  
00:05:24,139 --> 00:05:30,509  
this is called red shifting the only way

116  
00:05:28,379 --> 00:05:32,939  
to see that light as it arrives in our

117  
00:05:30,509 --> 00:05:33,319  
region of the universe is to look for

118  
00:05:32,939 --> 00:05:37,310  
that

119  
00:05:33,319 --> 00:05:39,800  
faint infrared glow by capturing it we

120  
00:05:37,310 --> 00:05:42,280  
will be able to create images of the

121  
00:05:39,800 --> 00:05:44,930  
first galaxies to form in the universe

122  
00:05:42,279 --> 00:05:47,269  
by witnessing the birth of the first

123  
00:05:44,930 --> 00:05:49,189  
stars and galaxies we deepen our

124  
00:05:47,269 --> 00:05:52,279  
knowledge of how the universe as we know

125  
00:05:49,189 --> 00:05:55,009  
it came to be how did we get from those

126  
00:05:52,279 --> 00:05:58,549  
first blazing stars to the islands of

127  
00:05:55,009 --> 00:06:00,740  
billions of stars we see today what will

128  
00:05:58,550 --> 00:06:02,379  
we learn about how galaxies grow and

129  
00:06:00,740 --> 00:06:05,220  
evolve

130  
00:06:02,379 --> 00:06:09,909  
how did the chaos of the early universe

131  
00:06:05,220 --> 00:06:12,220  
transform into order and structure NASA

132  
00:06:09,910 --> 00:06:15,820  
is currently building the James Webb

133  
00:06:12,220 --> 00:06:18,310  
Space Telescope with its huge infrared

134  
00:06:15,819 --> 00:06:20,980  
capturing mirror and distant orbit far

135  
00:06:18,310 --> 00:06:23,829  
beyond the moon Webb will allow us to

136  
00:06:20,980 --> 00:06:27,730  
view the cosmos as we've never seen it

137  
00:06:23,829 --> 00:06:29,859  
before Webb will search for signs of

138  
00:06:27,730 --> 00:06:34,210  
water vapor on planets around other

139  
00:06:29,860 --> 00:06:38,740  
stars it will take pictures of the

140  
00:06:34,209 --> 00:06:41,589  
universes infancy Webb will reveal the

141  
00:06:38,740 --> 00:06:45,970  
hidden stars and solar systems forming

142  
00:06:41,589 --> 00:06:48,399  
within cocoons of dust the answers to

143

00:06:45,970 --> 00:06:50,650  
some of the universe's biggest mysteries

144  
00:06:48,399 --> 00:06:53,679  
and more questions we haven't thought to

145  
00:06:50,649 --> 00:06:58,089  
ask are waiting out there for us in the

146  
00:06:53,680 --> 00:07:00,530  
form of infrared radiation all we have

147  
00:06:58,089 --> 00:07:15,528  
to do is look

148  
00:07:00,529 --> 00:07:15,528  
[Music]

149  
00:07:17,949 --> 00:07:23,088  
[Music]

150  
00:07:25,819 --> 00:07:29,379  
[Music]