



1
00:00:13,720 --> 00:00:10,130

[Music]

2
00:00:20,960 --> 00:00:18,019

light we all know it travels it well the

3
00:00:22,849 --> 00:00:20,970

speed of light or does it when it comes

4
00:00:24,349 --> 00:00:22,859

to the structure of space and time could

5
00:00:30,410 --> 00:00:24,359

light be the key to unlocking the final

6
00:00:32,089 --> 00:00:30,420

secrets of the universe answers may lie

7
00:00:33,410 --> 00:00:32,099

in the journey of two photons across

8
00:00:35,479 --> 00:00:33,420

seven billion light-years of space

9
00:00:39,530 --> 00:00:35,489

recorded by the Fermi gamma-ray Space

10
00:00:40,639 --> 00:00:39,540

Telescope and these two tiny particles

11
00:00:43,549 --> 00:00:40,649

have just opened up a whole new chapter

12
00:00:47,360 --> 00:00:43,559

an understanding of light gravity and

13
00:00:48,979 --> 00:00:47,370

the universe around us we're really

14

00:00:50,869 --> 00:00:48,989

excited because we've captured rare

15

00:00:52,810 --> 00:00:50,879

experimental evidence probing the

16

00:00:56,299 --> 00:00:52,820

fundamental structure of space and time

17

00:00:58,610 --> 00:00:56,309

meet NASA's gamma-ray detectives led by

18

00:00:59,720 --> 00:00:58,620

project scientist Julie McEnery they're

19

00:01:01,599 --> 00:00:59,730

searching for clues about the

20

00:01:04,160 --> 00:01:01,609

high-energy mysteries of our universe

21

00:01:06,289 --> 00:01:04,170

but they'll need more than a magnifying

22

00:01:10,380 --> 00:01:06,299

glass for this the team is one-of-a-kind

23

00:01:12,690 --> 00:01:10,390

tool the Fermi satellite

24

00:01:14,640 --> 00:01:12,700

family looks at gamma rays the highest

25

00:01:16,800 --> 00:01:14,650

energy form of life and it just

26

00:01:20,590 --> 00:01:16,810

surprised everyone with the discovery

27

00:01:24,399 --> 00:01:22,630

so you might be thinking to tiny

28

00:01:26,320 --> 00:01:24,409

particles of light why is that important

29

00:01:27,670 --> 00:01:26,330

well you need to take the very large and

30

00:01:29,980 --> 00:01:27,680

the very small

31

00:01:32,080 --> 00:01:29,990

together to understand the universe as a

32

00:01:33,940 --> 00:01:32,090

whole so far

33

00:01:35,710 --> 00:01:33,950

Einstein's theory of relativity which

34

00:01:38,200 --> 00:01:35,720

describes space and time as a smooth

35

00:01:40,060 --> 00:01:38,210

fabric that's distorted or bent by

36

00:01:41,770 --> 00:01:40,070

massive objects has been a spectacularly

37

00:01:44,400 --> 00:01:41,780

successful explanation of gravity and

38

00:01:46,330 --> 00:01:44,410

the large scale behavior of the universe

39

00:01:48,730 --> 00:01:46,340

whereas quantum mechanics another

40

00:01:50,230 --> 00:01:48,740

spectacularly successful model describes

41

00:01:52,060 --> 00:01:50,240

the workings of atoms subatomic

42

00:01:53,980 --> 00:01:52,070

particles and some of the fundamental

43

00:01:55,510 --> 00:01:53,990

forces of nature but scientists have

44

00:01:58,029 --> 00:01:55,520

never been able to reconcile the two

45

00:02:01,200 --> 00:01:58,039

both relativity and quantum mechanics

46

00:02:04,480 --> 00:02:01,210

are equally fundamental in their own

47

00:02:05,889 --> 00:02:04,490

regimes so scientists want to find a

48

00:02:07,719 --> 00:02:05,899

theory of everything just that describes

49

00:02:09,279 --> 00:02:07,729

the universe as a whole and the

50

00:02:11,140 --> 00:02:09,289

observations that we've made of these

51
00:02:12,699 --> 00:02:11,150
two photons with firming takes us one

52
00:02:14,170 --> 00:02:12,709
step closer to achieving the goal of

53
00:02:16,360 --> 00:02:14,180
having a theory of everything that

54
00:02:18,460 --> 00:02:16,370
combines the most successful aspects of

55
00:02:23,849 --> 00:02:18,470
quantum mechanics and relativity into

56
00:02:28,179 --> 00:02:26,679
to add to this puzzle other telescopes

57
00:02:29,500 --> 00:02:28,189
have observed gamma rays with different

58
00:02:31,690 --> 00:02:29,510
wavelengths arriving at Earth at

59
00:02:33,699 --> 00:02:31,700
different times according to Einstein's

60
00:02:36,130 --> 00:02:33,709
special theory of relativity all forms

61
00:02:38,709 --> 00:02:36,140
of electromagnetic radiation from radio

62
00:02:40,780 --> 00:02:38,719
and infrared to visible light to x-rays

63
00:02:43,149 --> 00:02:40,790

and even gamma rays moves at the same

64

00:02:45,550 --> 00:02:43,159

speed so what would explain these

65

00:02:47,589 --> 00:02:45,560

differences in arrival times one simple

66

00:02:50,410 --> 00:02:47,599

idea is that maybe the photons were just

67

00:02:51,970 --> 00:02:50,420

emitted at different times more

68

00:02:53,410 --> 00:02:51,980

interestingly though maybe there was

69

00:02:54,789 --> 00:02:53,420

something in the very fabric of space

70

00:02:57,520 --> 00:02:54,799

that was causing the higher energy

71

00:03:00,159 --> 00:02:57,530

particle to slow down if this is true

72

00:03:01,780 --> 00:03:00,169

could Einstein have been wrong could a

73

00:03:08,409 --> 00:03:01,790

higher energy particle move slower than

74

00:03:10,089 --> 00:03:08,419

the speed of light several ideas which

75

00:03:12,429 --> 00:03:10,099

attempt to reconcile relativity in

76
00:03:14,140 --> 00:03:12,439
quantum mechanics suggests that space

77
00:03:17,229 --> 00:03:14,150
and time are not actually smooth and

78
00:03:20,589 --> 00:03:17,239
uniform but are instead a seething froth

79
00:03:22,539 --> 00:03:20,599
when seen at the smallest scale like

80
00:03:24,039 --> 00:03:22,549
bubble wrap viewed from far away at

81
00:03:28,360 --> 00:03:24,049
human scales this texture would be

82
00:03:30,610 --> 00:03:28,370
invisible a low-energy long wavelength

83
00:03:34,270 --> 00:03:30,620
photon is unaffected by the lumpiness of

84
00:03:37,059 --> 00:03:34,280
space but a high-energy short wavelength

85
00:03:38,800 --> 00:03:37,069
photon is hindered by the Frog this

86
00:03:41,830 --> 00:03:38,810
makes it move more slowly than lower

87
00:03:43,599 --> 00:03:41,840
energy radiation so it breaks Einstein's

88
00:03:46,809 --> 00:03:43,609

law that all light particles must travel

89

00:03:48,550 --> 00:03:46,819

at the same speed however this

90

00:03:51,400 --> 00:03:48,560

explanation had little experimental

91

00:03:53,890 --> 00:03:51,410

proof either way until Fermi arrived

92

00:03:56,750 --> 00:03:53,900

[Music]

93

00:03:58,880 --> 00:03:56,760

we observed a gamma-ray burst a

94

00:04:00,380 --> 00:03:58,890

gamma-ray burst is a huge explosion that

95

00:04:02,060 --> 00:04:00,390

gamma ray bursts produced a large number

96

00:04:04,130 --> 00:04:02,070

of photons one of which had enormous

97

00:04:07,160 --> 00:04:04,140

energy very short wavelengths those

98

00:04:09,440 --> 00:04:07,170

photons traveled 7 billion years to

99

00:04:10,820 --> 00:04:09,450

reach us and yet the highest energy the

100

00:04:13,370 --> 00:04:10,830

shortest wavelength photon arrived

101

00:04:15,350 --> 00:04:13,380

within 900 milliseconds of the lower

102

00:04:17,390 --> 00:04:15,360

energy photons and that's a little bit

103

00:04:19,280 --> 00:04:17,400

like racing to speedboats one through

104

00:04:21,020 --> 00:04:19,290

water and the other to molasses and

105

00:04:24,830 --> 00:04:21,030

having them arrive at the same time it

106

00:04:26,540 --> 00:04:24,840

just doesn't happen because Fermi saw no

107

00:04:29,930 --> 00:04:26,550

delay in the arrival time of the two

108

00:04:32,390 --> 00:04:29,940

photons it confirms that space and time

109

00:04:34,160 --> 00:04:32,400

is smooth and continuous as Einstein had

110

00:04:35,870 --> 00:04:34,170

predicted and it shuts the door on

111

00:04:37,940 --> 00:04:35,880

several theories of everything that had

112

00:04:47,580 --> 00:04:37,950

predicted that space and time might be

113

00:04:52,890 --> 00:04:50,500

so if space-time really isn't just

114

00:04:55,180 --> 00:04:52,900

invisible bubble wrap what is it

115

00:04:57,130 --> 00:04:55,190

Fermi has eliminated some ideas from the

116

00:04:59,080 --> 00:04:57,140

mix and that means we're one step closer

117

00:05:02,110 --> 00:04:59,090

to potentially unifying relativity and

118

00:05:04,060 --> 00:05:02,120

quantum mechanics after all science is a

119

00:05:05,950 --> 00:05:04,070

process of elimination and unless we

120

00:05:07,420 --> 00:05:05,960

keep eliminating we may never know if

121

00:05:07,990 --> 00:05:07,430

this theory of everything actually

122

00:05:10,090 --> 00:05:08,000

exists

123

00:05:11,890 --> 00:05:10,100

hidden in the math of our universe but

124

00:05:14,320 --> 00:05:11,900

for now we'll have to keep searching for

125

00:05:19,220 --> 00:05:14,330

clues beyond our small planet because

