



1
00:00:20,980 --> 00:00:19,060
one hundred years ago one visionary set

2
00:00:23,919 --> 00:00:20,990
forth upon a scientific journey of the

3
00:00:27,339 --> 00:00:23,929
mind so profound that it forever changed

4
00:00:28,390 --> 00:00:27,349
the way we live our lives and view the

5
00:00:36,650 --> 00:00:28,400
universe

6
00:00:41,250 --> 00:00:39,299
practicing physics on the sly and with

7
00:00:43,259 --> 00:00:41,260
very little personal interaction with

8
00:00:46,200 --> 00:00:43,269
the scientific establishment at the time

9
00:00:49,079 --> 00:00:46,210
this unknown patent clerk in Bern

10
00:00:51,869 --> 00:00:49,089
Switzerland named Albert Einstein wrote

11
00:00:53,610 --> 00:00:51,879
five seminal papers in 1905 that

12
00:00:56,430 --> 00:00:53,620
encompassed the whole of the universe

13
00:01:00,719 --> 00:00:56,440

from the workings of the atom and out

14

00:01:01,920 --> 00:01:00,729

through space and time during the course

15

00:01:04,380 --> 00:01:01,930

of that one year

16

00:01:07,050 --> 00:01:04,390

the brash 26 year old Einstein helped

17

00:01:09,870 --> 00:01:07,060

clinched the then controversial case for

18

00:01:12,149 --> 00:01:09,880

the existence of atoms he proposed that

19

00:01:14,730 --> 00:01:12,159

light is made of particles of energy and

20

00:01:17,969 --> 00:01:14,740

he began to turn the tables on Isaac

21

00:01:19,820 --> 00:01:17,979

Newton's laws of motion laws revered for

22

00:01:22,590 --> 00:01:19,830

more than 200 years

23

00:01:24,899 --> 00:01:22,600

he said that space and time were

24

00:01:28,109 --> 00:01:24,909

relative depending on one's frame of

25

00:01:30,840 --> 00:01:28,119

reference traveling at light speed time

26

00:01:33,719 --> 00:01:30,850

slows down so that one second were

27

00:01:35,430 --> 00:01:33,729

linger for an eternity he also realized

28

00:01:39,139 --> 00:01:35,440

that matter and energy are

29

00:01:41,490 --> 00:01:39,149

interchangeable $E = MC^2$

30

00:01:43,649 --> 00:01:41,500

Einstein's theories at the stage for the

31

00:01:46,280 --> 00:01:43,659

technological revolution that defined

32

00:01:50,429 --> 00:01:46,290

the 20th century

33

00:01:53,539 --> 00:01:50,439

lasers electronic sensors nuclear fusion

34

00:01:55,750 --> 00:01:53,549

all point back to one man and one

35

00:01:58,730 --> 00:01:55,760

miraculous year

36

00:02:00,110 --> 00:01:58,740

Einstein had a way of working but it was

37

00:02:01,970 --> 00:02:00,120

really his stubbornness that made him

38

00:02:04,640 --> 00:02:01,980

stand out he didn't take for granted

39

00:02:07,880 --> 00:02:04,650

what other people were saying he

40

00:02:09,830 --> 00:02:07,890

realized that gravity was different from

41

00:02:11,810 --> 00:02:09,840

all the other forces of nature general

42

00:02:17,620 --> 00:02:11,820

relativity says that gravity is not a

43

00:02:23,060 --> 00:02:20,780

Einstein's theories on gravity space and

44

00:02:25,190 --> 00:02:23,070

time led to startling outcomes that in

45

00:02:28,100 --> 00:02:25,200

some cases Einstein himself could not

46

00:02:30,770 --> 00:02:28,110

believe the universe is expanding and is

47

00:02:33,440 --> 00:02:30,780

not static as was thought at the time we

48

00:02:36,380 --> 00:02:33,450

now believe this expansion is caused by

49

00:02:39,230 --> 00:02:36,390

a big bang his equations also revealed

50

00:02:42,170 --> 00:02:39,240

that regions we now call black holes can

51
00:02:47,960 --> 00:02:42,180
cause space to buckle and bring time to

52
00:02:53,300 --> 00:02:50,720
recent technology has propelled an

53
00:02:55,670 --> 00:02:53,310
explosion of new findings raising new

54
00:03:00,630 --> 00:02:55,680
questions that Einstein's theories do

55
00:03:02,940 --> 00:03:00,640
not address what powered the Big Bang

56
00:03:06,390 --> 00:03:02,950
what happens at the edge of a black hole

57
00:03:08,340 --> 00:03:06,400
and what is the mysterious dark energy

58
00:03:10,160 --> 00:03:08,350
that is now accelerating the expansion

59
00:03:13,890 --> 00:03:10,170
of the universe

60
00:03:16,440 --> 00:03:13,900
we've been at such crossroads before the

61
00:03:19,290 --> 00:03:16,450
scientific revolutions spawned by Isaac

62
00:03:21,810 --> 00:03:19,300
Newton and Albert Einstein were a result

63
00:03:24,449 --> 00:03:21,820

of the growing inadequacy of established

64

00:03:27,479 --> 00:03:24,459

theories of their times we're sort of at

65

00:03:29,280 --> 00:03:27,489

that stage again we are despite our

66

00:03:32,130 --> 00:03:29,290

vastly more sophisticated understanding

67

00:03:34,710 --> 00:03:32,140

now in 1905 we now have results

68

00:03:36,420 --> 00:03:34,720

primarily obtained from Astrophysical

69

00:03:40,350 --> 00:03:36,430

observations which was simply not

70

00:03:42,570 --> 00:03:40,360

accommodated in our theories this is

71

00:03:45,479 --> 00:03:42,580

where NASA's beyond Einsteins program

72

00:03:48,750 --> 00:03:45,489

begins scientists have set a course a

73

00:03:51,150 --> 00:03:48,760

well coordinated mix of facility class

74

00:03:53,820 --> 00:03:51,160

spacecraft probes and Pathfinder

75

00:03:56,400 --> 00:03:53,830

missions each with powerful new

76
00:03:59,699 --> 00:03:56,410
technology to explore the extremes of

77
00:04:02,280 --> 00:03:59,709
nature the Big Bang black holes and dark

78
00:04:04,920 --> 00:04:02,290
energy for it is here that the current

79
00:04:07,620 --> 00:04:04,930
theories begin to crack and answers are

80
00:04:09,750 --> 00:04:07,630
revealed to really understand the laws

81
00:04:11,970 --> 00:04:09,760
of nature we have to go to these extreme

82
00:04:14,880 --> 00:04:11,980
environments and study them to give a

83
00:04:16,890 --> 00:04:14,890
hint of the true fundamental laws of

84
00:04:18,719 --> 00:04:16,900
nature people are talking about doing

85
00:04:21,479 --> 00:04:18,729
precision cosmology for the first time

86
00:04:22,680 --> 00:04:21,489
because it used to be cosmology well we

87
00:04:25,409 --> 00:04:22,690
have a rough idea how big the universe

88
00:04:26,700 --> 00:04:25,419

is maybe to a factor of two or three but

89

00:04:28,560 --> 00:04:26,710

now with these new measurements we're

90

00:04:30,060 --> 00:04:28,570

really getting a handle on the overall

91

00:04:33,240 --> 00:04:30,070

density and structure of the universe

92

00:04:36,560 --> 00:04:33,250

and what they're telling us is not what

93

00:04:44,010 --> 00:04:39,810

well the biggest mystery today in all of

94

00:04:46,610 --> 00:04:44,020

science is dark energy why is the

95

00:04:51,929 --> 00:04:46,620

universe speeding up

96

00:04:54,360 --> 00:04:51,939

it's a fantastic puzzle and were quite

97

00:04:57,749 --> 00:04:54,370

confident that when we figure it out

98

00:05:00,980 --> 00:04:57,759

it's going to give us answers about

99

00:05:03,540 --> 00:05:00,990

other important puzzles as well since

100

00:05:06,600 --> 00:05:03,550

1998 something totally unexpected

101
00:05:08,820 --> 00:05:06,610
happened which is we discovered that not

102
00:05:11,939 --> 00:05:08,830
only our universe is expanding this

103
00:05:14,899 --> 00:05:11,949
expansion is accelerating you know this

104
00:05:21,360 --> 00:05:14,909
is a classical who ordered that type

105
00:05:24,179 --> 00:05:21,370
situation in 70% or so is dark energy in

106
00:05:25,709 --> 00:05:24,189
the universe you know about 70% of the

107
00:05:26,600 --> 00:05:25,719
surface of the earth is covered with

108
00:05:33,439 --> 00:05:26,610
water

109
00:05:36,230 --> 00:05:33,449
was this is the situation wearing a

110
00:05:38,909 --> 00:05:36,240
mysterious force propelling the universe

111
00:05:40,890 --> 00:05:38,919
ironically Einstein proposed such a

112
00:05:43,260 --> 00:05:40,900
force to counter the inward pull of

113
00:05:45,499 --> 00:05:43,270

gravity and to keep the universe static

114

00:05:48,629 --> 00:05:45,509

which was the belief a hundred years ago

115

00:05:53,100 --> 00:05:48,639

he called this the cosmological constant

116

00:05:55,469 --> 00:05:53,110

a vacuum energy of empty space when

117

00:05:58,409 --> 00:05:55,479

Edwin Hubble discovered the expansion of

118

00:06:00,659 --> 00:05:58,419

the universe in the 1920s Einstein

119

00:06:03,779 --> 00:06:00,669

called the cosmological constant his

120

00:06:06,360 --> 00:06:03,789

greatest mistake but the mysterious dark

121

00:06:08,369 --> 00:06:06,370

energy we see today may well be a

122

00:06:11,640 --> 00:06:08,379

manifestation of this cosmological

123

00:06:15,959 --> 00:06:11,650

constant Einstein was perhaps right

124

00:06:18,179 --> 00:06:15,969

after all richard fineman and others who

125

00:06:20,820 --> 00:06:18,189

developed quantum theory realized that

126
00:06:23,519 --> 00:06:20,830
empty space was full of temporary or

127
00:06:26,670 --> 00:06:23,529
virtual particles continually forming

128
00:06:28,769 --> 00:06:26,680
and destroying themselves physicists

129
00:06:31,290 --> 00:06:28,779
began to suspect that the vacuum of

130
00:06:33,570 --> 00:06:31,300
space ought to have a repulsive form of

131
00:06:35,939 --> 00:06:33,580
energy generated for these virtual

132
00:06:38,339 --> 00:06:35,949
particles but they could not dictate its

133
00:06:40,890 --> 00:06:38,349
magnitude we still do not know whether

134
00:06:43,200 --> 00:06:40,900
the highly accelerated expansion in the

135
00:06:44,939 --> 00:06:43,210
early universe called inflation and the

136
00:06:48,659 --> 00:06:44,949
current accelerated expansion due to

137
00:06:51,360 --> 00:06:48,669
dark energy are related a space-based

138
00:06:53,429 --> 00:06:51,370

mission called the dark energy probe to

139

00:06:55,769 --> 00:06:53,439

be jointly implemented by NASA and the

140

00:06:57,749 --> 00:06:55,779

Department of Energy is being planned to

141

00:06:59,589 --> 00:06:57,759

measure the expansion accurately enough

142

00:07:01,749 --> 00:06:59,599

to learn whether this energy is

143

00:07:04,839 --> 00:07:01,759

constant property of empty space as

144

00:07:06,820 --> 00:07:04,849

Einstein conjectured or whether it shows

145

00:07:09,129 --> 00:07:06,830

signs of the richer structure that is

146

00:07:11,739 --> 00:07:09,139

predicted in modern unification theories

147

00:07:15,699 --> 00:07:11,749

this mission will be a major step in

148

00:07:17,799 --> 00:07:15,709

tackling the mystery of dark energy for

149

00:07:19,719 --> 00:07:17,809

the first time we actually have an

150

00:07:22,839 --> 00:07:19,729

inventory of the universe but if you

151

00:07:27,279 --> 00:07:22,849

look at the accounting 95% of the stuff

152

00:07:32,499 --> 00:07:27,289

is in forms yet to be fully understood

153

00:07:35,980 --> 00:07:32,509

and so we know a lot but we understand

154

00:07:38,739 --> 00:07:35,990

much less and among the 5% that

155

00:07:41,170 --> 00:07:38,749

scientists call ordinary matter lie yet