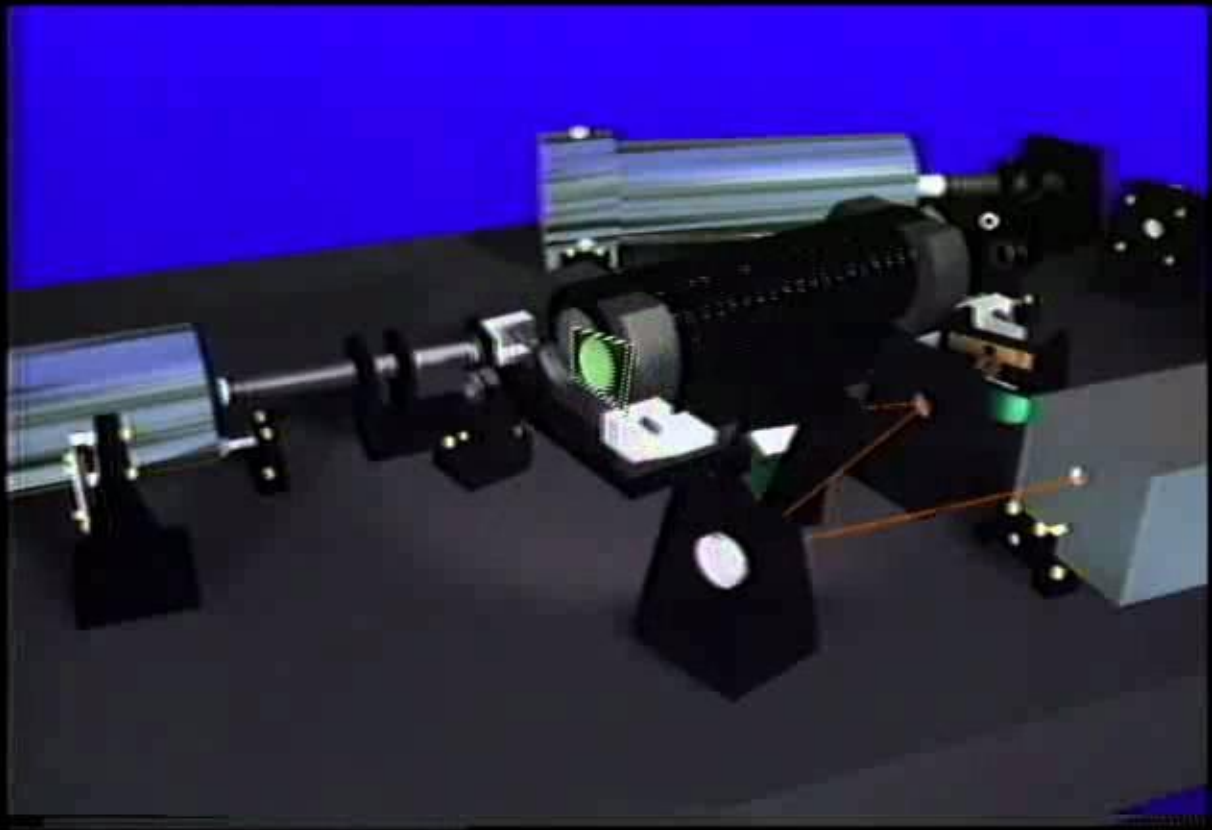

1
00:00:00,000 --> 00:00:34,700
you

2
00:00:40,440 --> 00:00:37,950
we have ignition and liftoff of Columbia

3
00:00:44,820 --> 00:00:40,450
on an ambitious tims a international

4
00:00:46,950 --> 00:00:44,830
research flight the critical fluid bite

5
00:00:48,660 --> 00:00:46,960
scattering experiment isn't exciting

6
00:00:50,850 --> 00:00:48,670
part of the second United States

7
00:00:53,460 --> 00:00:50,860
microgravity payload that will fly

8
00:00:55,590 --> 00:00:53,470
aboard the space shuttle Columbia this

9
00:00:57,540 --> 00:00:55,600
precise experiment will challenge the

10
00:01:01,020 --> 00:00:57,550
universal understanding of some physical

11
00:01:03,110 --> 00:01:01,030
phenomena the experiment is named Zeno

12
00:01:06,149 --> 00:01:03,120
in honor of an ancient Greek philosopher

13
00:01:09,600 --> 00:01:06,159

Zeno evelia who first pondered the

14
00:01:12,330 --> 00:01:09,610
concept of infinity Zeno's most famous

15
00:01:13,920 --> 00:01:12,340
paradox of infinity demonstrates that an

16
00:01:16,740 --> 00:01:13,930
infinite number of successively smaller

17
00:01:20,219 --> 00:01:16,750
steps can be squeezed into the distance

18
00:01:22,140 --> 00:01:20,229
between two points Zeno's paradox is

19
00:01:24,840 --> 00:01:22,150
analogous to the modern-day Zeno

20
00:01:26,760 --> 00:01:24,850
experiment where a series of minut steps

21
00:01:29,430 --> 00:01:26,770
are made toward the critical temperature

22
00:01:31,500 --> 00:01:29,440
of a fluid the critical temperature of a

23
00:01:34,020 --> 00:01:31,510
fluid is the highest temperature at

24
00:01:37,380 --> 00:01:34,030
which it's liquid and vapor phases can

25
00:01:39,690 --> 00:01:37,390
coexist at low temperatures both the

26
00:01:42,840 --> 00:01:39,700
liquid and its vapor can be observed and

27
00:01:45,900 --> 00:01:42,850
exhibit on earth a visible meniscus or

28
00:01:48,450 --> 00:01:45,910
boundary at temperatures above the

29
00:01:51,870 --> 00:01:48,460
critical temperature only a single phase

30
00:01:54,390 --> 00:01:51,880
exists the Zeno experiment will begin in

31
00:01:56,640 --> 00:01:54,400
this supercritical single phase region

32
00:01:59,190 --> 00:01:56,650
and will progress toward the critical

33
00:02:01,050 --> 00:01:59,200
point to study fluid properties as the

34
00:02:04,350 --> 00:02:01,060
fluid prepares to separate into two

35
00:02:07,350 --> 00:02:04,360
phases this is an example of a second

36
00:02:09,630 --> 00:02:07,360
order phase transition other examples of

37
00:02:11,430 --> 00:02:09,640
second order phase transitions include

38
00:02:13,949 --> 00:02:11,440

normal conductors superconductor

39
00:02:17,430 --> 00:02:13,959
transitions and magnetic transitions at

40
00:02:19,410 --> 00:02:17,440
the Curie point at the critical

41
00:02:21,990 --> 00:02:19,420
temperatures of these second order phase

42
00:02:24,570 --> 00:02:22,000
transitions the materials fluctuate

43
00:02:26,790 --> 00:02:24,580
between different states it's these

44
00:02:29,850 --> 00:02:26,800
fluctuations that scientists want to

45
00:02:31,619 --> 00:02:29,860
study much progress has been made in

46
00:02:33,809 --> 00:02:31,629
theory and measurement of these phase

47
00:02:35,460 --> 00:02:33,819
transitions but the Earth's gravity

48
00:02:38,040 --> 00:02:35,470
makes it impossible to do a careful

49
00:02:39,750 --> 00:02:38,050
study of the secondary liquid vapor

50
00:02:42,570 --> 00:02:39,760
phase change at the critical

51
00:02:45,059 --> 00:02:42,580
temperature fortunately the space

52
00:02:47,280 --> 00:02:45,069
environment now permits a new generation

53
00:02:50,220 --> 00:02:47,290
of experiments to test the best theories

54
00:02:52,800 --> 00:02:50,230
currently available zeno principal

55
00:02:55,050 --> 00:02:52,810
investigator Robert gammon explains why

56
00:02:59,490 --> 00:02:55,060
the gaseous elements xenon was chosen

57
00:03:01,830 --> 00:02:59,500
for this experiment we believe that

58
00:03:04,170 --> 00:03:01,840
xenon is an ideal fluid for studying the

59
00:03:06,089 --> 00:03:04,180
liquid vapor critical point it's

60
00:03:09,720 --> 00:03:06,099
available in very high purity it's a

61
00:03:11,550 --> 00:03:09,730
simple monatomic spherical atomic fluid

62
00:03:14,819 --> 00:03:11,560
and it has a convenient critical

63
00:03:16,770 --> 00:03:14,829

temperature it's better than all the

64
00:03:18,569 --> 00:03:16,780
other systems we could think of for very

65
00:03:21,119 --> 00:03:18,579
precise studies close to the critical

66
00:03:23,240 --> 00:03:21,129
point because it's not limited by purity

67
00:03:26,039 --> 00:03:23,250
and not limited by crystal perfection

68
00:03:28,009 --> 00:03:26,049
the xeno experiment is being done in the

69
00:03:30,809 --> 00:03:28,019
microgravity environment of space

70
00:03:33,000 --> 00:03:30,819
because on earth as you near the

71
00:03:35,520 --> 00:03:33,010
critical temperature the Earth's gravity

72
00:03:39,089 --> 00:03:35,530
causes the fluid to stratify or form

73
00:03:40,699 --> 00:03:39,099
layers this distorts the sample but the

74
00:03:43,259 --> 00:03:40,709
microgravity environment of space

75
00:03:45,089 --> 00:03:43,269
permits a very close approach to the

76
00:03:47,939 --> 00:03:45,099
critical temperature before the

77
00:03:50,580 --> 00:03:47,949
stratification begins during this

78
00:03:53,129 --> 00:03:50,590
experiment careful control of the sample

79
00:03:55,319 --> 00:03:53,139
density and thermal environment enables

80
00:03:57,150 --> 00:03:55,329
precise measurement to be made within a

81
00:04:00,270 --> 00:03:57,160
few millions of a degree of the critical

82
00:04:03,059 --> 00:04:00,280
temperature 100 to 1,000 times closer

83
00:04:04,890 --> 00:04:03,069
than is possible on earth we might

84
00:04:08,009 --> 00:04:04,900
compare the experiment to climbing a

85
00:04:10,400 --> 00:04:08,019
mountain the goal is to analyze the area

86
00:04:13,619 --> 00:04:10,410
closest to the peak the critical point

87
00:04:16,259 --> 00:04:13,629
to do that the climber makes minut moves

88
00:04:19,740 --> 00:04:16,269

toward that point as the climber gets

89
00:04:22,439 --> 00:04:19,750
closer some unusual things happen it's

90
00:04:25,110 --> 00:04:22,449
fascinating xenon near the critical

91
00:04:28,140 --> 00:04:25,120
point is a billion times softer than

92
00:04:30,450 --> 00:04:28,150
water the system doesn't know whether it

93
00:04:32,399 --> 00:04:30,460
wants to be a liquid or a vapor and it

94
00:04:34,320 --> 00:04:32,409
readily goes back and forth between the

95
00:04:36,719 --> 00:04:34,330
two and has nearly an infinite heat

96
00:04:40,050 --> 00:04:36,729
capacity in the process of this sloshing

97
00:04:41,550 --> 00:04:40,060
back and forth it turns milky white it's

98
00:04:43,830 --> 00:04:41,560
in this state that important

99
00:04:45,510 --> 00:04:43,840
measurements will be made as the

100
00:04:47,550 --> 00:04:45,520
temperature of the fluid sample and the

101
00:04:49,980 --> 00:04:47,560
xeno experiment approaches the critical

102
00:04:53,279 --> 00:04:49,990
temperature density fluctuations

103
00:04:53,430 --> 00:04:53,289
increase dramatically a laser serves as

104
00:05:41,580 --> 00:04:53,440
a

105
00:05:43,680 --> 00:05:41,590
the science requirements for the

106
00:05:46,170 --> 00:05:43,690
experiment and developed the flight

107
00:05:49,200 --> 00:05:46,180
instrument the instrument was fabricated

108
00:05:51,870 --> 00:05:49,210
and tested by Ball Aerospace the heart

109
00:05:55,190 --> 00:05:51,880
of the experiment is a high pressure

110
00:05:59,480 --> 00:05:55,200
sample sale located in the thermostat

111
00:06:01,560 --> 00:05:59,490
the this sample is eliminated by a laser

112
00:06:03,240 --> 00:06:01,570
which is brought around through the

113
00:06:06,510 --> 00:06:03,250

apparatus with mirrors and a beam

114
00:06:10,560 --> 00:06:06,520
splitter and in along the axis from

115
00:06:12,210 --> 00:06:10,570
either end the sample is located close

116
00:06:14,909 --> 00:06:12,220
to the center of this thermostat and

117
00:06:18,360 --> 00:06:14,919
scatters light to this photo multiplier

118
00:06:20,250 --> 00:06:18,370
at a small angle or through a bending

119
00:06:23,220 --> 00:06:20,260
mirror to a second photo multiplier so

120
00:06:25,740 --> 00:06:23,230
that we can see two angles at once the

121
00:06:28,980 --> 00:06:25,750
other principle detectors in the

122
00:06:30,750 --> 00:06:28,990
experiment are photo diodes which sample

123
00:06:32,880 --> 00:06:30,760
the light behind this partially

124
00:06:35,100 --> 00:06:32,890
transmitting mirror and there's one at

125
00:06:36,780 --> 00:06:35,110
the other end as well the Zeno

126
00:06:39,060 --> 00:06:36,790
instrument will fly aboard the space

127
00:06:42,120 --> 00:06:39,070
shuttle Columbia as part of the second

128
00:06:44,220 --> 00:06:42,130
United States microgravity payload this

129
00:06:46,830 --> 00:06:44,230
series of payloads has been sponsored by

130
00:06:49,980 --> 00:06:46,840
the NASA office of life and microgravity

131
00:06:51,750 --> 00:06:49,990
Sciences and applications these payloads

132
00:06:53,460 --> 00:06:51,760
include some of the most challenging

133
00:06:56,790 --> 00:06:53,470
experiments to be conducted in space

134
00:06:58,940 --> 00:06:56,800
during this decade Zeno will provide

135
00:07:00,960 --> 00:06:58,950
data that is not observable on earth

136
00:07:04,020 --> 00:07:00,970
theories will be challenged and

137
00:07:05,400 --> 00:07:04,030
experience will be expanded improved

138
00:07:07,380 --> 00:07:05,410

understanding of second-order

139
00:07:09,780 --> 00:07:07,390
transitions will help in here