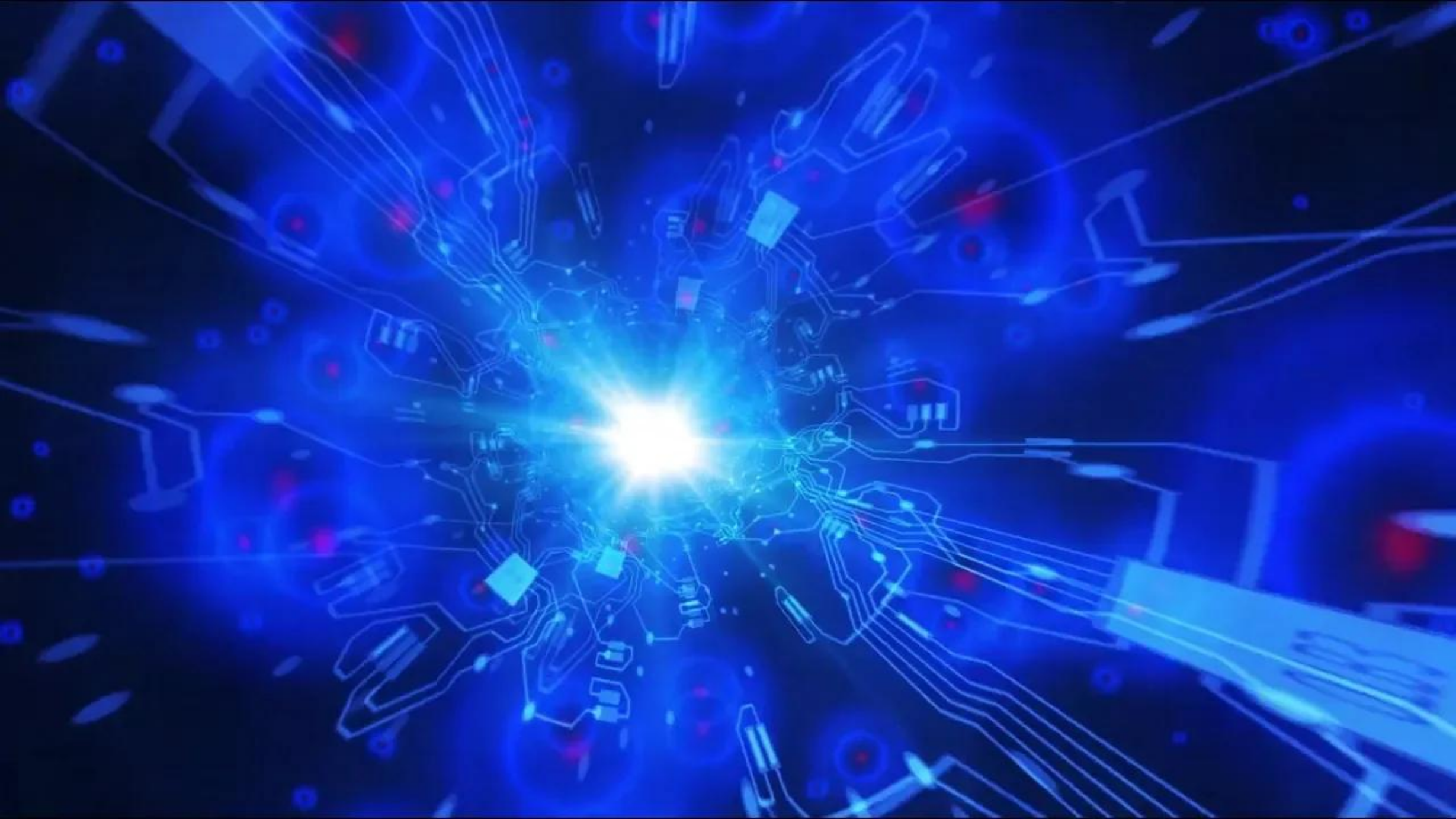

1
00:00:00,266 --> 00:00:02,335
[Music]

2
00:00:02,368 --> 00:00:05,038
[Cold Atom Lab]

3
00:00:05,071 --> 00:00:08,441
[The Coolest Experiment
in the Universe]

4
00:00:08,474 --> 00:00:11,478
[Dr. Eric Cornell] We are
dominated by the very small.

5
00:00:12,212 --> 00:00:14,114
We don't even
think about it.

6
00:00:14,514 --> 00:00:15,815
We take our phone
out of our pocket,

7
00:00:15,848 --> 00:00:18,084
we don't think of our
phone as being that small

8
00:00:18,117 --> 00:00:19,652
but there are
billions of things-

9
00:00:19,685 --> 00:00:22,055
of transistors
inside your phone.

10
00:00:22,789 --> 00:00:26,159
We're used to high-tech
always moving

11
00:00:26,192 --> 00:00:27,827

smaller, smaller, smaller.

12
00:00:27,860 --> 00:00:30,163
But we're running up
against some limits

13
00:00:30,196 --> 00:00:33,132
and those limits are that as
things get smaller and smaller,

14
00:00:33,165 --> 00:00:35,802
the physics that
controls how things act;

15
00:00:35,835 --> 00:00:37,804
the underlying science-

16
00:00:37,837 --> 00:00:40,673
instead of being the
old school physics,

17
00:00:40,706 --> 00:00:42,341
which is called
“classical physics”,

18
00:00:42,374 --> 00:00:44,343
which you can think
of as pool balls

19
00:00:44,376 --> 00:00:45,378
rattling around
on a table

20
00:00:45,411 --> 00:00:47,247
and clacking
into each other.

21
00:00:47,647 --> 00:00:49,382
As you get very, very small,

22
00:00:49,415 --> 00:00:50,683
instead of acting like
these little balls,

23
00:00:50,716 --> 00:00:52,018
they act more and
more like waves.

24
00:00:52,051 --> 00:00:55,154
And the underlying physics is
not called “classical physics”,

25
00:00:55,187 --> 00:00:57,356
it's now called
“quantum physics”.

26
00:00:57,389 --> 00:00:59,225
Where things start
getting complicated

27
00:00:59,258 --> 00:01:00,593
and harder to understand

28
00:01:00,626 --> 00:01:02,395
is when you have
collections of atoms

29
00:01:02,428 --> 00:01:03,463
or collections of electrons,

30
00:01:03,496 --> 00:01:05,832
bouncing off each other, passing
through each other

31
00:01:05,865 --> 00:01:07,800
on their way through our
tiny little transistors,

32
00:01:07,833 --> 00:01:12,138

to turn on and off the ones and
zeros in our tiny computers.

33
00:01:12,171 --> 00:01:15,408
These problems are
hugely more complex.

34
00:01:15,441 --> 00:01:18,478
And so often times we have to do
experiments to understand them.

35
00:01:18,744 --> 00:01:21,614
That's where the ultra-cold
temperatures come in.

36
00:01:22,247 --> 00:01:23,315
[Dr. Nicholas Bigelow] If
you cool atoms down

37
00:01:23,349 --> 00:01:26,486
to some of the coldest
temperatures you can imagine,

38
00:01:26,519 --> 00:01:29,422
colder than any other place
in the natural universe,

39
00:01:29,455 --> 00:01:31,424
the atoms are moving
very, very slowly.

40
00:01:31,457 --> 00:01:32,558
And if you're going to
make some measurements

41
00:01:32,592 --> 00:01:35,328
about their properties, if
they're moving slowly,

42
00:01:35,361 --> 00:01:36,229

you can make that
measurement

43
00:01:36,262 --> 00:01:38,098
a lot more precisely.

44
00:01:38,598 --> 00:01:39,132
[Dr. Ethan Elliot]
If all the atoms

45
00:01:39,165 --> 00:01:40,066
in this room right now

46
00:01:40,100 --> 00:01:43,302
are moving around at
770 miles per hour,

47
00:01:43,335 --> 00:01:45,838
the speeds that
the atoms are moving,

48
00:01:45,871 --> 00:01:47,673
once they're cooled,
is slower than

49
00:01:47,706 --> 00:01:50,610
1/1000th of a
mile per hour.

50
00:01:50,643 --> 00:01:53,146
A cold atom is a
controllable atom.

51
00:01:53,179 --> 00:01:56,249
You let them out of the trap
and they just float.

52
00:01:56,716 --> 00:01:59,185
[Dr. Jason Williams] We are
cooling the atoms down to

53
00:01:59,218 --> 00:02:00,920
a fraction of a
billionth of a degree

54
00:02:00,953 --> 00:02:02,488
above absolute zero.

55
00:02:02,521 --> 00:02:03,856
And at temperatures
so low,

56
00:02:03,889 --> 00:02:07,560
we can easily see these
atoms for tens of seconds

57
00:02:07,593 --> 00:02:09,862
and study and see
their dynamics

58
00:02:09,895 --> 00:02:12,665
and how they interact
with each other.

59
00:02:12,831 --> 00:02:14,734
[Dr. Ron Walsworth] To do that
we have to be in space.

60
00:02:14,767 --> 00:02:16,402
We have to take
quantum matter

61
00:02:16,435 --> 00:02:18,738
and quantum technologies
into space.

62
00:02:18,771 --> 00:02:20,406
And we have to
work hard to learn

63
00:02:20,439 --> 00:02:22,808
how to use quantum
technologies in space.

64
00:02:22,841 --> 00:02:25,411
And the Cold Atom
Laboratory is the first

65
00:02:25,444 --> 00:02:27,213
dedicated laboratory
that'll allow us

66
00:02:27,246 --> 00:02:28,715
to do this
sort of work.

67
00:02:29,215 --> 00:02:30,183
[Dr. Brian Demarco] These
types of experiments

68
00:02:30,216 --> 00:02:32,585
are the most challenging
table-top experiments

69
00:02:32,618 --> 00:02:33,886
that take
place on Earth.

70
00:02:33,919 --> 00:02:35,588
So to take this up to
the space station

71
00:02:35,621 --> 00:02:38,658
is a whole new level where
we'll have to operate remotely

72
00:02:38,691 --> 00:02:41,794
and have a robust
working instrument.

73
00:02:41,827 --> 00:02:43,296
The Cold Atom Lab
will also allow us

74
00:02:43,329 --> 00:02:45,231
to free those type
of experiments

75
00:02:45,264 --> 00:02:46,465
from the constraints of gravity

76
00:02:46,498 --> 00:02:48,501
that plague researchers
on the ground.

77
00:02:48,534 --> 00:02:49,902
Gravity always drags atoms

78
00:02:49,935 --> 00:02:51,837
to the bottom of the
traps that we use

79
00:02:51,870 --> 00:02:54,274
and the Cold Atom Lab, we
don't have that problem.

80
00:02:54,574 --> 00:02:55,408
[Dr. Wolfgang Ketterle]
When we discovered

81
00:02:55,441 --> 00:02:57,977
Bose-Einstein
Condensation in 1995,

82
00:02:58,010 --> 00:03:00,613
the experiment was
complicated and difficult.

83
00:03:00,646 --> 00:03:03,316

I would have never imagined
that it is possible to

84
00:03:03,349 --> 00:03:06,752
do such experiments now
on the space station.

85
00:03:06,785 --> 00:03:08,487
With Bose-Einstein Condensates,

86
00:03:08,520 --> 00:03:10,923
we'll reach nanokelvin
temperatures,

87
00:03:10,956 --> 00:03:14,293
so all the atoms have an
extremely low energy.

88
00:03:14,326 --> 00:03:17,697
So therefore, going to
micro-gravity eliminates

89
00:03:17,730 --> 00:03:20,833
a number of limitations
for the experiments.

90
00:03:21,066 --> 00:03:24,537
[Cornell] Ultra-cold acts
like a magnifying glass.

91
00:03:24,570 --> 00:03:28,374
It expands the effects of
quantum mechanics.

92
00:03:28,407 --> 00:03:29,976
That's really
the power of these

93
00:03:30,009 --> 00:03:33,346
very low temperatures of the

Cold Atom Laboratory

94
00:03:33,379 --> 00:03:35,348
as we can learn
about these things,

95
00:03:35,381 --> 00:03:37,450
as we get colder
and colder yet.

96
00:03:38,617 --> 00:03:39,785
[LOGO: NASA Jet
Propulsion Laboratory