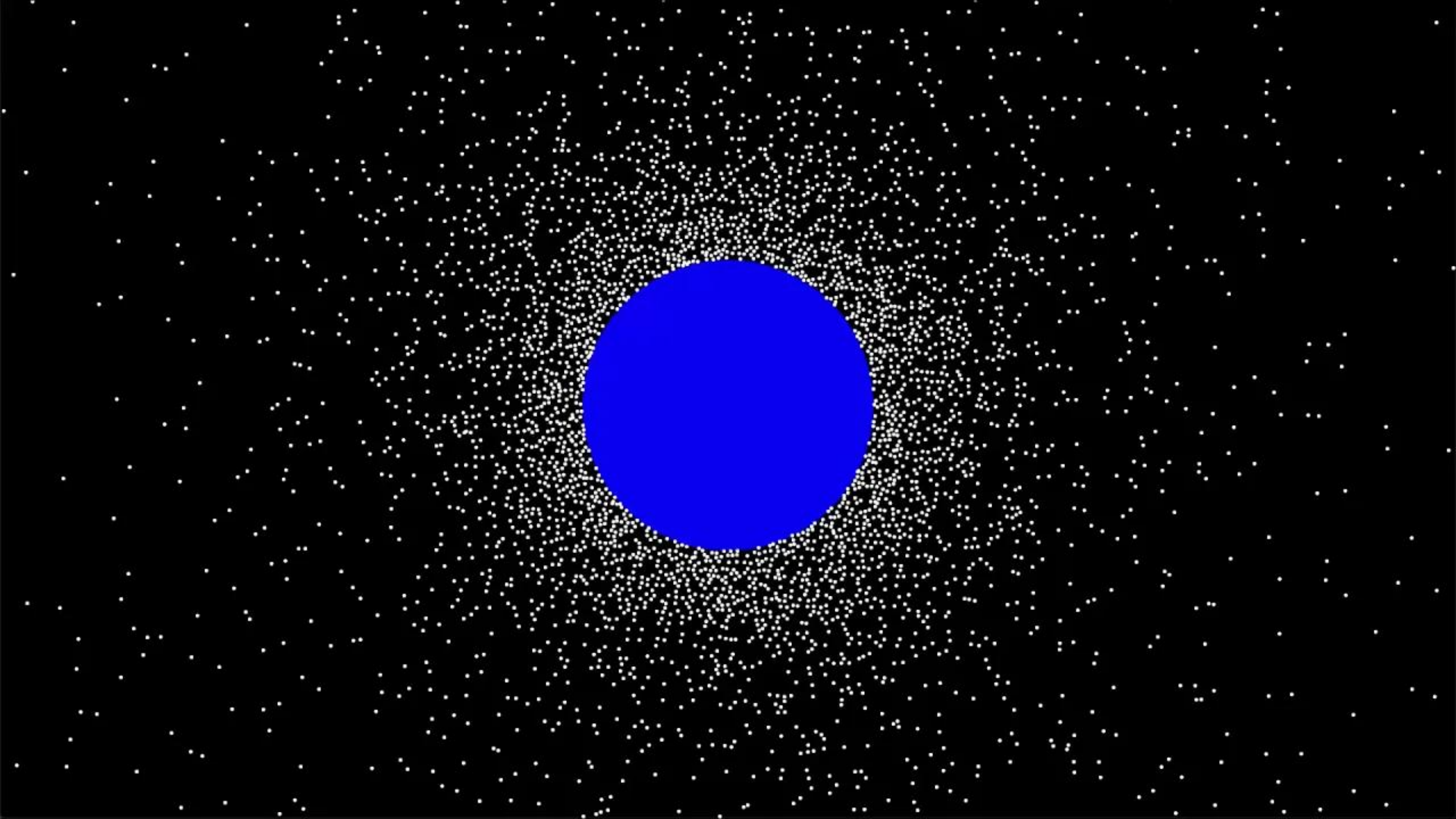

1
00:00:05,849 --> 00:00:03,809
everybody knows that if you have an

2
00:00:07,409 --> 00:00:05,859
alien in your spaceship the best course

3
00:00:08,580 --> 00:00:07,419
of action is to blow a hole in a window

4
00:00:11,400 --> 00:00:08,590
and the alien will get sucked out

5
00:00:12,870 --> 00:00:11,410
problem solved so we all know if you've

6
00:00:14,250 --> 00:00:12,880
got some air under normal pressure and

7
00:00:16,590 --> 00:00:14,260
there's a vacuum next to it and the air

8
00:00:17,790 --> 00:00:16,600
will rush over to fill the vacuum but

9
00:00:19,529 --> 00:00:17,800
the Earth's atmosphere is in the normal

10
00:00:21,300 --> 00:00:19,539
pressure and there's nothing between the

11
00:00:22,800 --> 00:00:21,310
atmosphere in the vacuum of space so why

12
00:00:25,200 --> 00:00:22,810
doesn't all the air on Earth get sucked

13
00:00:27,480 --> 00:00:25,210

into space the answer of course is

14
00:00:28,980 --> 00:00:27,490
gravity gravity is holding the

15
00:00:31,080 --> 00:00:28,990
atmosphere down but how does that work

16
00:00:32,939 --> 00:00:31,090
exactly how does gravity keep the air in

17
00:00:35,940 --> 00:00:32,949
my room with a constant pressure and not

18
00:00:37,650 --> 00:00:35,950
rushing off into space well to

19
00:00:38,910 --> 00:00:37,660
understand how that it works you could

20
00:00:42,150 --> 00:00:38,920
have think about what the atmosphere

21
00:00:44,220 --> 00:00:42,160
actually is the atmosphere of the air is

22
00:00:46,440 --> 00:00:44,230
a gas a mixture most of nitrogen and

23
00:00:49,920 --> 00:00:46,450
oxygen like all gases it's just a bunch

24
00:00:51,000 --> 00:00:49,930
of molecules flying around now we're

25
00:00:53,069 --> 00:00:51,010
used to thinking of the atmosphere in

26
00:00:54,990 --> 00:00:53,079
terms of air pressure but to understand

27
00:00:57,270 --> 00:00:55,000
that you have to consider the motion of

28
00:00:58,680 --> 00:00:57,280
individual molecules let's do some

29
00:01:01,889 --> 00:00:58,690
thought experiments in a simplified

30
00:01:03,630 --> 00:01:01,899
universe let's say the universe contain

31
00:01:04,319 --> 00:01:03,640
nothing at all except for some gas

32
00:01:08,130 --> 00:01:04,329
molecules

33
00:01:10,320 --> 00:01:08,140
tiny little objects they behave like

34
00:01:11,850 --> 00:01:10,330
other objects were in space the gas

35
00:01:14,250 --> 00:01:11,860
molecules would just move in straight

36
00:01:16,020 --> 00:01:14,260
lines not changing direction unless they

37
00:01:17,250 --> 00:01:16,030
happen to collide with each other the

38
00:01:20,160 --> 00:01:17,260

universe would just continue like this

39
00:01:21,690 --> 00:01:20,170
gas molecules moving around eventually

40
00:01:24,890 --> 00:01:21,700
we're closer together on formal nebulae

41
00:01:27,359 --> 00:01:24,900
and stars that's another story

42
00:01:31,260 --> 00:01:27,369
so suppose we had apply it into the mix

43
00:01:33,270 --> 00:01:31,270
how will that change things BAM suddenly

44
00:01:35,490 --> 00:01:33,280
our universe is a strong gravity well

45
00:01:36,960 --> 00:01:35,500
all the nearby gas molecules are

46
00:01:38,280 --> 00:01:36,970
attracted down to the planet so they

47
00:01:40,140 --> 00:01:38,290
tend to move in that direction now

48
00:01:41,609 --> 00:01:40,150
adding a planet like that has created a

49
00:01:43,140 --> 00:01:41,619
whole bunch of potential energy so

50
00:01:43,469 --> 00:01:43,150
things speed up and slosh around for a

51
00:01:45,420 --> 00:01:43,479
bit

52
00:01:51,470 --> 00:01:45,430
but eventually they settle there let's

53
00:01:57,320 --> 00:01:53,930
what do we find the planet has acquired

54
00:01:58,160 --> 00:01:57,330
an atmosphere not only that it's one

55
00:02:00,770 --> 00:01:58,170
where the density of the atmosphere

56
00:02:02,270 --> 00:02:00,780
decreases as you get higher most of the

57
00:02:03,530 --> 00:02:02,280
molecules near the planet's surface are

58
00:02:04,880 --> 00:02:03,540
bouncing around colliding with each

59
00:02:05,420 --> 00:02:04,890
other and colliding with the objects

60
00:02:07,070 --> 00:02:05,430
around them

61
00:02:09,470 --> 00:02:07,080
it's those collisions that make air

62
00:02:11,540 --> 00:02:09,480
pressure but the ones off in space such

63
00:02:13,070 --> 00:02:11,550

as following ballistic trajectories and

64
00:02:14,750 --> 00:02:13,080
because there's so few molecules there's

65
00:02:20,150 --> 00:02:14,760
far fewer collisions and so very little

66
00:02:21,560 --> 00:02:20,160
pressure of any so we can see there's no

67
00:02:23,660 --> 00:02:21,570
reason for the atmosphere to fly off

68
00:02:25,970 --> 00:02:23,670
into space all of the atmosphere has

69
00:02:27,440 --> 00:02:25,980
been pulled down towards the planet the

70
00:02:28,970 --> 00:02:27,450
only reason why air rushes to fill up

71
00:02:30,560 --> 00:02:28,980
vacuum down earth is because the

72
00:02:33,320 --> 00:02:30,570
molecules are bouncing around so much

73
00:02:35,240 --> 00:02:33,330
they just fill up any empty space so

74
00:02:36,740 --> 00:02:35,250
look at this in more detail it's the

75
00:02:38,660 --> 00:02:36,750
bottom of the screen is the surface of

76
00:02:40,210 --> 00:02:38,670
the planet we've dropped a bunch of gas

77
00:02:42,350 --> 00:02:40,220
in here again and it's settling down

78
00:02:44,120 --> 00:02:42,360
let's speed up again until it reaches

79
00:02:54,949 --> 00:02:44,130
some kind of equilibrium just lets

80
00:02:58,880 --> 00:02:57,289
again we see a pressure gradient with a

81
00:03:00,500 --> 00:02:58,890
vacuum at the top and sea level at the

82
00:03:02,000 --> 00:03:00,510
bottom you can also see there's no

83
00:03:03,229 --> 00:03:02,010
compelling reason for the molecules at

84
00:03:05,660 --> 00:03:03,239
the top of the atmosphere to whiz off

85
00:03:07,390 --> 00:03:05,670
into space some of them do but gravity

86
00:03:09,979 --> 00:03:07,400
keeps most of them returning to Earth

87
00:03:11,599 --> 00:03:09,989
another thing you can see is that there

88
00:03:13,610 --> 00:03:11,609

really isn't an edge to the atmosphere

89
00:03:15,080 --> 00:03:13,620
it just gets thinner and thinner and the

90
00:03:18,080 --> 00:03:15,090
molecules get further and further apart

91
00:03:19,910 --> 00:03:18,090
he never really ends even in the space

92
00:03:21,559 --> 00:03:19,920
between galaxies the hardest vacuum