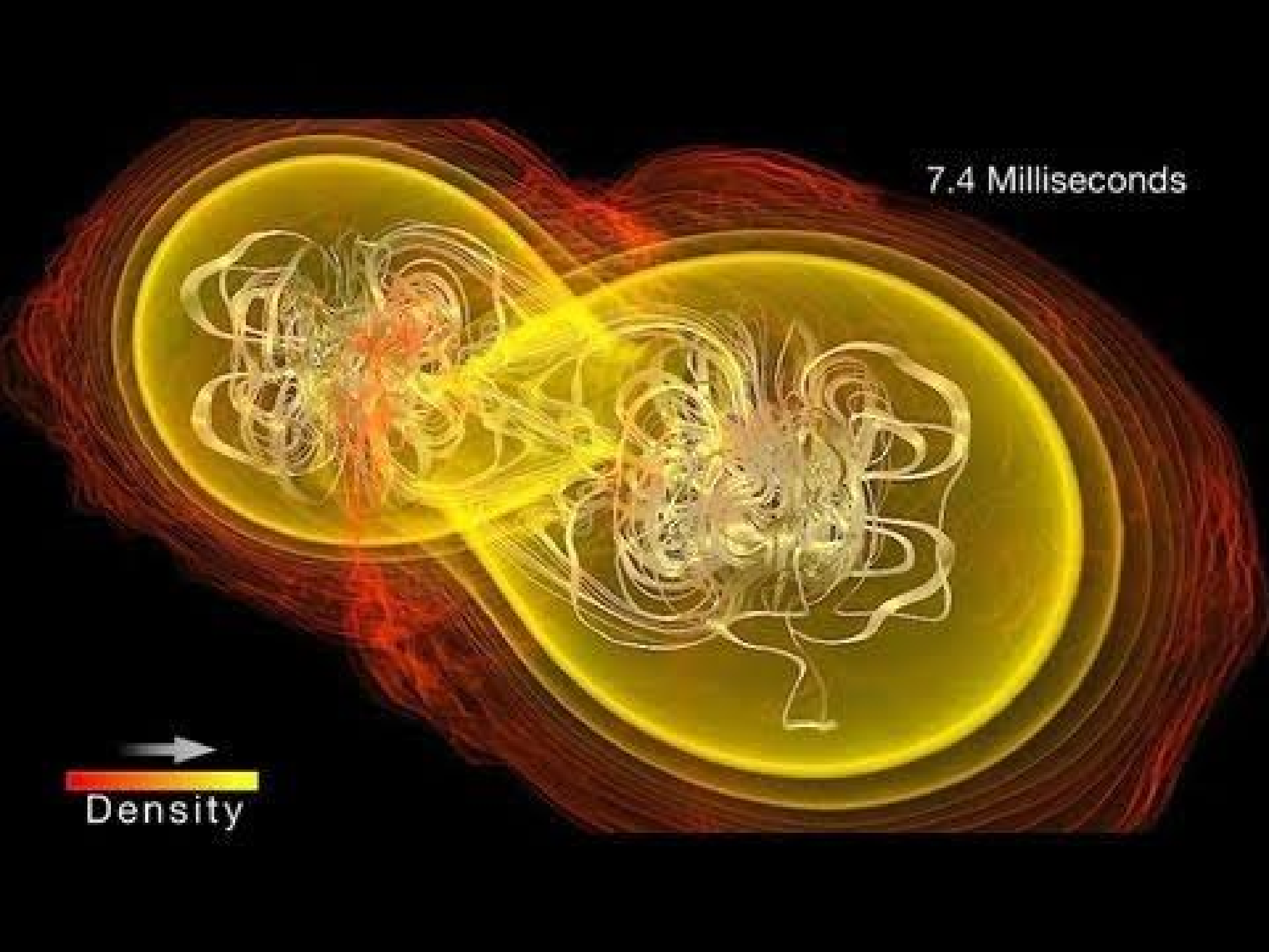
7.4 Milliseconds
Density

1
00:00:00,270 --> 00:00:12,440
Music

2
00:00:12,460 --> 00:00:16,480
Narrator: Every day or two, on average, satellites detect

3
00:00:16,500 --> 00:00:20,550
a massive explosion somewhere in the sky. These are gamma-ray

4
00:00:20,570 --> 00:00:24,620
bursts, the brightest blasts in the universe. They're thought to be

5
00:00:24,640 --> 00:00:28,690
caused by jets of matter moving near the speed of light associated with the births

6
00:00:28,710 --> 00:00:32,750
of black holes. Gamma-ray bursts that last longer than two seconds

7
00:00:32,770 --> 00:00:36,830
are the most common and are thought to result from the death of a massive star.

8
00:00:36,850 --> 00:00:41,040
Shorter bursts proved much more elusive. In fact,

9
00:00:41,060 --> 00:00:45,060
even some of their basic properties were unknown until NASA's Swift satellite

10
00:00:45,080 --> 00:00:49,160
began work in 2004. Astronomers suspected that crashing

11
00:00:49,180 --> 00:00:53,210
neutron stars could explain short bursts.

12
00:00:53,230 --> 00:00:57,310
A neutron star is what remains when a star several times the mass

13
00:00:57,330 --> 00:01:01,390

of the sun collapses and explodes. With more than the sun's

14
00:01:01,410 --> 00:01:05,430
mass packed in a sphere less than 18 miles across, these objects are

15
00:01:05,450 --> 00:01:09,510
incredibly dense. Just a sugar-cube-size piece of neutron star

16
00:01:09,530 --> 00:01:13,560
can weigh as much as all the water in the Great Lakes. When two

17
00:01:13,580 --> 00:01:17,660
orbiting neutron stars collide, they merge and form a black hole, releasing

18
00:01:17,680 --> 00:01:21,680
enormous amounts of energy in the process. Armed with state-of-the-art

19
00:01:21,700 --> 00:01:25,700
supercomputer models, scientists have shown that colliding neutron stars

20
00:01:25,720 --> 00:01:29,760
can produce the energetic jet required for a gamma-ray burst.

21
00:01:29,780 --> 00:01:33,830
Earlier simulations demonstrated that mergers could make black holes. Others

22
00:01:33,850 --> 00:01:37,910
had shown that the high-speed particle jets needed to make a gamma-ray burst would

23
00:01:37,930 --> 00:01:41,960
continue if placed in the swirling wreckage of a recent merger.

24
00:01:41,980 --> 00:01:46,000
Now, the simulations reveal the middle step of the process

25
00:01:46,020 --> 00:01:50,070
--how the merging stars' magnetic field organizes itself

26
00:01:50,090 --> 00:01:54,110
into outwardly directed components capable of forming a jet.

27
00:01:54,130 --> 00:01:58,150
The Damiana supercomputer at Germany's Max Planck Institute for Gravitational

28
00:01:58,170 --> 00:02:02,230
Physics needed six weeks to reveal the details of a process that

29
00:02:02,250 --> 00:02:06,270
unfolds in just 35 thousandths of a second.

30
00:02:06,290 --> 00:02:10,360
The new simulation shows two neutron stars merging to

31
00:02:10,380 --> 00:02:14,420
form a black hole surrounded by super-hot plasma. On

32
00:02:14,440 --> 00:02:18,480
the left is a map of the density of the stars as they scramble their matter into a dense,

33
00:02:18,500 --> 00:02:22,630
hot cloud of swirling debris. On the right is a map of

34
00:02:22,650 --> 00:02:26,670
the magnetic fields, with blue representing magnetic strength a billion times

35
00:02:26,690 --> 00:02:30,720
greater than the sun's. The simulation

36
00:02:30,740 --> 00:02:34,760
shows the same disorderly behavior of the matter and magnetic fields.

37
00:02:34,780 --> 00:02:38,810
Both structures gradually become more organized, but what's important

38
00:02:38,830 --> 00:02:42,880

here is the white magnetic field. Amidst this incredible

39
00:02:42,900 --> 00:02:46,940
turmoil, the white field has taken on the character of a jet, although

40
00:02:46,960 --> 00:02:50,980
no matter is flowing through it when the simulation ends.

41
00:02:51,000 --> 00:02:55,020
Showing that magnetic fields suddenly become organized as jets

42
00:02:55,040 --> 00:02:59,070
provides scientists with the missing link. It confirms that

43
00:02:59,090 --> 00:03:03,130
merging neutron stars can indeed produce short gamma-ray bursts.

44
00:03:03,150 --> 00:03:07,190
At this moment, somewhere across the cosmos, it's about

45
00:03:07,210 --> 00:03:11,210
to happen again. [Explosion]