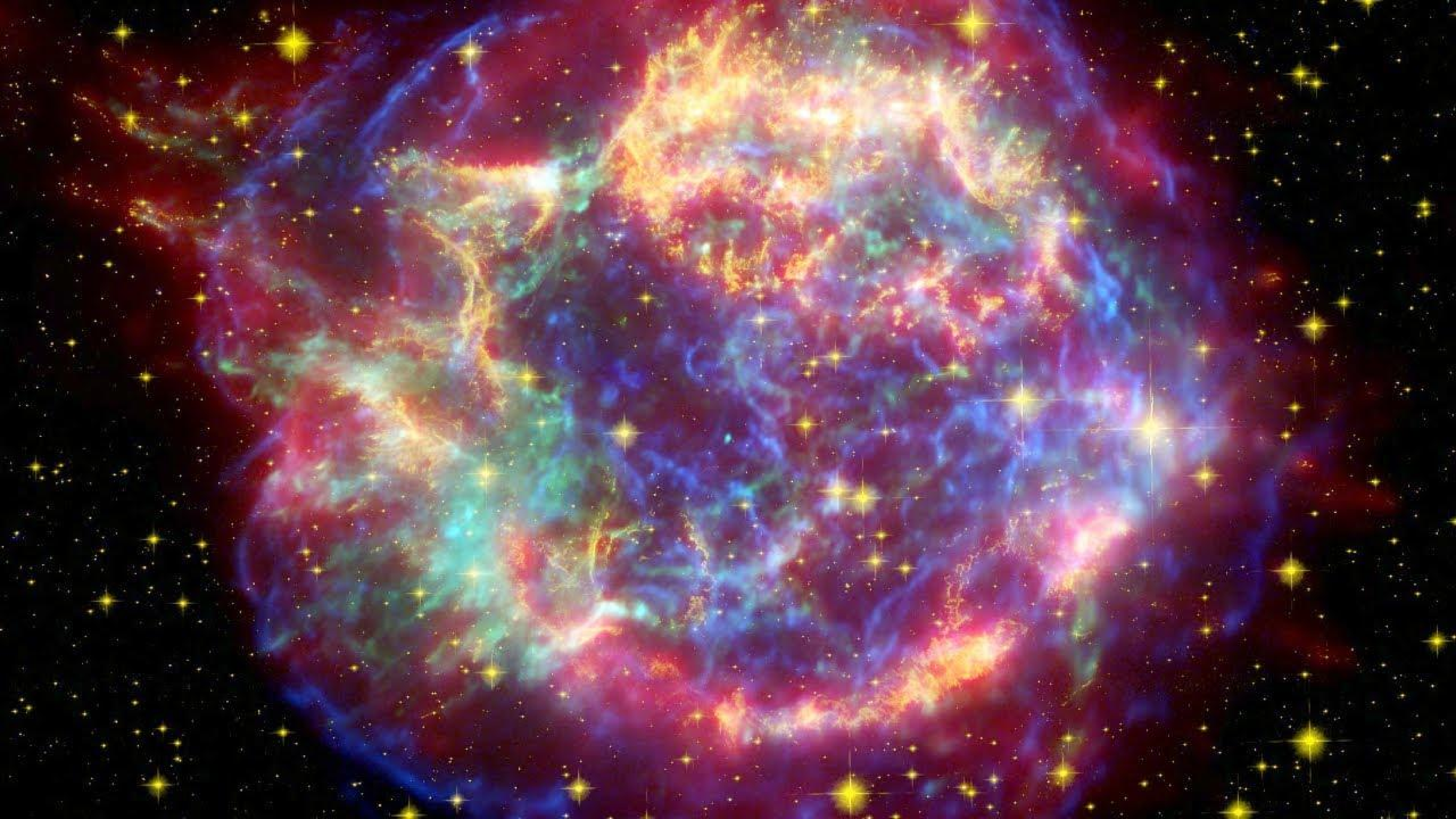

1
00:00:11,030 --> 00:00:08,010
Music

2
00:00:11,050 --> 00:00:15,080
Narrator: About two or three times a century, a massive in our galaxy

3
00:00:15,100 --> 00:00:19,090
explodes. The star's core may survive as a

4
00:00:19,110 --> 00:00:23,110
neutron star or a black hole, but the rest of it rushes into space

5
00:00:23,130 --> 00:00:27,150
as swiftly expanding debris behind a powerful shockwave.

6
00:00:27,170 --> 00:00:31,190
As the supernova remnant grows, it sweeps up interstellar gas and

7
00:00:31,210 --> 00:00:35,200
gradually decelerates. Yet even thousands of years later,

8
00:00:35,220 --> 00:00:39,220
its imprint on the galaxy remains impressive. Exploding stars

9
00:00:39,240 --> 00:00:43,240
and their remnants have long been suspected of producing cosmic rays, some of

10
00:00:43,260 --> 00:00:47,260
the fastest matter in the universe. Where and how these protons,

11
00:00:47,280 --> 00:00:51,280
electrons and atomic nuclei are boosted to such high speeds has been an

12
00:00:51,300 --> 00:00:55,280
enduring mystery. Now, observations of two supernova

13
00:00:55,300 --> 00:00:59,310

remnants by NASA's Fermi Gamma-ray Space Telescope provide new insights.

14
00:00:59,330 --> 00:01:03,320
Because cosmic rays carry electric charge, their

15
00:01:03,340 --> 00:01:07,330
direction changes as they travel through magnetic fields. By the time the particles

16
00:01:07,350 --> 00:01:11,350
reach us, their paths are completely scrambled. We can't trace them back to

17
00:01:11,370 --> 00:01:15,360
their sources. So scientists must locate their origins by indirect means,

18
00:01:15,380 --> 00:01:19,380
which is where Fermi comes in. The interaction of high energy particles

19
00:01:19,400 --> 00:01:23,390
with light and ordinary matter can produce gamma rays, the most powerful form of light.

20
00:01:23,410 --> 00:01:27,410
Unlike cosmic rays, gamma rays travel to us straight from their sources.

21
00:01:27,430 --> 00:01:31,410
In 1949,

22
00:01:31,430 --> 00:01:35,430
physicist Enrico Fermi worked out what he called "magnetized clouds"

23
00:01:35,450 --> 00:01:39,450
could accelerate cosmic rays. Later studies showed that a

24
00:01:39,470 --> 00:01:43,490
variant of his method, called Fermi acceleration worked especially well in supernova

25
00:01:43,510 --> 00:01:47,510
remnants. Confined by a magnetic field,

26
00:01:47,530 --> 00:01:51,520
high-energy particles move around randomly. Sometimes they cross the shock

27
00:01:51,540 --> 00:01:55,540
wave. With each round trip, they gain about 1 percent of their original

28
00:01:55,560 --> 00:01:59,560
energy. After dozens to hundreds of crossings, the particle

29
00:01:59,580 --> 00:02:03,590
is moving near the speed of light and is finally able to escape. If the

30
00:02:03,610 --> 00:02:07,610
supernova remnant resides near a dense molecular cloud, some of those

31
00:02:07,630 --> 00:02:11,630
escaping cosmic rays may strike the gas, and produce gamma rays.

32
00:02:11,640 --> 00:02:15,650
But electrons and protons make gamma rays in different ways.

33
00:02:15,670 --> 00:02:19,670
Cosmic ray electrons do so when they're deflected by passing near

34
00:02:19,700 --> 00:02:23,690
the nucleus of an atom. Accelerated protons

35
00:02:23,710 --> 00:02:27,720
may collide with an ordinary proton and produce a short-lived particle called a

36
00:02:27,740 --> 00:02:31,740
neutral pion. These pions quickly decay into a pair of gamma

37
00:02:31,760 --> 00:02:35,760
rays. At their brightest, both types

38
00:02:35,780 --> 00:02:39,790

of emission look very similar. Only with sensitive measurements at lower

39
00:02:39,810 --> 00:02:43,820
gamma-ray energies can scientists determine which process is responsible.

40
00:02:43,840 --> 00:02:47,850
Now, Fermi observations have done just that.

41
00:02:47,870 --> 00:02:51,890
They conclusively show these supernova remnants are accelerating protons.

42
00:02:51,910 --> 00:02:55,930
When they strike protons in nearby molecular clouds, they produce pions...

43
00:02:55,950 --> 00:02:59,970
and ultimately the gamma-ray emission Fermi sees.

44
00:02:59,990 --> 00:03:04,010
NASA's Fermi has detected gamma rays from many more supernova remnants,

45
00:03:04,040 --> 00:03:08,030
but the jury is still out on whether accelerated protons are always responsible

46
00:03:08,050 --> 00:03:12,060
and what their maximum energies may be. Nevertheless, the Fermi

47
00:03:12,080 --> 00:03:16,090
team has taken a major step--a century after the discovery of cosmic rays--

48
00:03:16,110 --> 00:03:20,110
in establishing just where they arise. Something that would satisfy,

49
00:03:20,130 --> 00:03:24,130
but certainly not surprise, the original Fermi.

50
00:03:24,150 --> 00:03:26,150
Music fades