1
00:00:00,010 --> 00:00:04,010
Narrator: In 2011, NASA's Swift satellite

2
00:00:04,030 --> 00:00:08,040
caught an X-ray outburst from a small galaxy

3
00:00:08,060 --> 00:00:12,060
3.8 billion light-years away. Within a couple of days, researchers realized

4
00:00:12,080 --> 00:00:16,130
they were witnessing the aftermath of a tidal disruption event--a star

5
00:00:16,150 --> 00:00:20,180
ripped apart by the monster black hole at the galaxy's center.

6
00:00:20,200 --> 00:00:24,210
Some of the stellar material fell toward the black hole, forming

7
00:00:24,230 --> 00:00:28,260
an accretion disk and a jet pointed in our direction.

8
00:00:28,280 --> 00:00:32,320
Erin Kara: Tidal disruption events offer us this rare view

9
00:00:32,340 --> 00:00:36,420
at the most common kind of supermassive black hole in the universe, these so-called

10
00:00:36,440 --> 00:00:40,550
dormant supermassive black holes. Ninety percent of black holes

11
00:00:40,570 --> 00:00:44,690
in the universe don't have a lot of hot material orbiting around

12
00:00:44,710 --> 00:00:48,850
them, they don't form these accretion disks, and so we can't observe

13
00:00:48,870 --> 00:00:52,890

them. Tidal disruption events, where the stellar debris

14
00:00:52,910 --> 00:00:56,930
causes the formation of a temporary accretion disk, offers

15
00:00:56,950 --> 00:01:00,960
us a way to probe this probe this population of supermassive black holes.

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00:01:00,980 --> 00:01:05,010
Narrator: Swift monitored the outburst's progress and was joined

17
00:01:05,030 --> 00:01:09,040
by the European Space Agency's XMM-Newton observatory,

18
00:01:09,060 --> 00:01:13,090
and the Japanese Suzaku satellite. Recently,

19
00:01:13,110 --> 00:01:17,210
astronomers introduced a new analysis technique that for the first time allows

20
00:01:17,230 --> 00:01:21,350
them to peer deep into the gravitational well of a normally quiescent black hole.

21
00:01:21,370 --> 00:01:25,450
Called X-ray reverberation mapping, the

22
00:01:25,470 --> 00:01:29,530
method charts the region close to the black hole using light echoes from X-ray flashes,

23
00:01:29,550 --> 00:01:33,630
similar to the way sonar uses sound to map the ocean floor.

24
00:01:33,650 --> 00:01:37,650
Erin: X-ray reverberation mapping has been

25
00:01:37,670 --> 00:01:41,690
very successful at probing the accretion flow in

26
00:01:41,710 --> 00:01:45,720
well-established accretion disk structures, but had never been used

27
00:01:45,740 --> 00:01:49,790
to look at tidal disruption events. My collaborator at the

28
00:01:49,810 --> 00:01:53,840
University of Maryland and I were having lunch one day, and she says

29
00:01:53,860 --> 00:01:57,900
"Has anyone ever looked at tidal disruption events with X-ray

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00:01:57,920 --> 00:02:01,990
reverberation mapping?" That night I stayed late at the office and

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00:02:02,010 --> 00:02:06,070
just tried it out on this data from Swift J1644

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00:02:06,090 --> 00:02:10,180
and much to my surprise the result was

33
00:02:10,200 --> 00:02:14,310
amazing and I could see that we were looking at

34
00:02:14,330 --> 00:02:18,460
the structure of the inner accretion flow around a normally

35
00:02:18,480 --> 00:02:22,530
dormant black hole for the first time. It's not like a normal accretion flow

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00:02:22,550 --> 00:02:26,600
in an active galaxy that's a flat disk, this is

37
00:02:26,620 --> 00:02:30,710
something that is extremely puffy, very turbulent, and

38
00:02:30,730 --> 00:02:34,830

we are measuring flashes of X-ray emission deep within this

39
00:02:34,850 --> 00:02:38,930
newly formed accretion disk. Narrator: Stellar

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00:02:38,950 --> 00:02:43,070
material streamed into the developing disk, churning it into a thick, chaotic

41
00:02:43,090 --> 00:02:47,250
whirlpool of X-ray emitting gas, funneling toward the central black hole.

42
00:02:47,270 --> 00:02:51,440
Deep inside this cavity, multiple X-ray flares

43
00:02:51,460 --> 00:02:55,500
erupted, providing a flash that echoed throughout the region.

44
00:02:55,520 --> 00:02:59,580
Erin: Previously, astronomers had thought that the X-ray emission

45
00:02:59,600 --> 00:03:03,640
is coming from far out in a jet, but we're finding

46
00:03:03,660 --> 00:03:07,750
with these observations is that the X-ray emission is coming from

47
00:03:07,770 --> 00:03:11,880
flares very close to the supermassive black hole. And we can

48
00:03:11,900 --> 00:03:16,030
use these observations to probe properties of the black hole

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00:03:16,050 --> 00:03:20,230
itself. For instance, we found that the mass of the black hole is something

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00:03:20,250 --> 00:03:24,410
on the order of a million times the mass of the sun.

51
00:03:24,430 --> 00:03:28,450
Narrator: The first observations of X-ray reverberations from deep inside an

52
00:03:28,470 --> 00:03:32,510
accretion disk are providing new insights into a rarely observed class

53
00:03:32,530 --> 00:03:36,580
of black holes. They're also laying the groundwork for a better

54
00:03:36,600 --> 00:03:40,680
understanding of tidal disruption events, and the black holes they illuminate.

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00:03:48,900 --> 00:03:44,790
[Music]