1
00:00:00,790 --> 00:00:04,720
\h The Chandra X-ray Observatory orbits high above the Earth,

2
00:00:04,720 --> 00:00:07,620
\h peering into the blackest reaches of space.

3
00:00:07,620 --> 00:00:10,440
\h Exploring the most menacing and magnificent features of the

4
00:00:10,440 --> 00:00:14,490
\h cosmos, this remarkable telescope is revealing what our eyes

5
00:00:14,490 --> 00:00:30,090
\h can't, taking us beyond visible light.

6
00:00:30,090 --> 00:00:36,620
\h Peering into the dark with its X-ray vision, NASA's Chandra X-ray Observatory is helping

7
00:00:36,620 --> 00:00:41,310
\h to unravel one of astronomy's most perplexing enigmas.

8
00:00:41,310 --> 00:00:48,870
\h Clusters of starlit galaxies and searing hot gas somehow stay together, even though the stars and gas

9
00:00:48,870 --> 00:00:54,700
\h themselves don't have enough mass -- or gravity -- to explain their bond.

10
00:00:54,700 --> 00:01:01,380
\h What cosmic ingredient is lurking in the darkness, undetectable by any of our telescopes,

11
00:01:01,380 --> 00:01:06,370
\h holding these spinning groups together when they should be flung apart?

12
00:01:06,370 --> 00:01:10,170
\h TANANBAUM: And, to hold the gas and the galaxies in place, you have to have this additional material.

13
00:01:10,170 --> 00:01:20,870

\h You can compute how much there is -- it's about, again, close to 10 times more than we see in the gas a

14
00:01:20,870 --> 00:01:27,500
\h And this material, because it doesn't radiate x-rays, it doesn't radiate light, it doesn't radiate in the infrare

15
00:01:27,500 --> 00:01:33,550
\h we feel the force of its gravity, we know it's there but we can't see it. So we call it dark material, dark ma

16
00:01:33,550 --> 00:01:39,330
\h Light waves from normal matter can be detected by a variety of telescopes, such as optical,

17
00:01:39,330 --> 00:01:44,090
\h X-ray, infrared, gamma-ray and more.

18
00:01:44,090 --> 00:01:52,190
\h Dark matter, on the other hand, is visible only through its gravitational effects on the matter we can see

19
00:01:52,190 --> 00:01:59,160
\h In August 2006, Chandra and other telescopes working together found direct proof of dark

20
00:01:59,160 --> 00:02:05,680
\h matter with a breakthrough discovery in a galaxy cluster known as the Bullet Cluster.

21
00:02:05,680 --> 00:02:12,600
\h When the Bullet Cluster's galaxies merged, the clouds of gas slowed down due to friction,

22
00:02:12,600 --> 00:02:17,090
\h but the galaxies themselves slipped through the collision.

23
00:02:17,090 --> 00:02:21,400
\h TANANBAUM: The galaxies and the dark matter, they act more like individual particles,

24
00:02:21,400 --> 00:02:23,980
\h and so they interact through the force of gravity.

25
00:02:23,980 --> 00:02:29,770
\h But they don't behave like a gas or a fluid, and it tells us something about the interactions of the dark ma

26
00:02:29,770 --> 00:02:33,180
\h it doesn't interact with itself other than through the force of gravity.

27
00:02:33,180 --> 00:02:38,750
\h And we have actually physically separated -- -we haven't personally separated, but in this Bullet Cluste

28
00:02:38,750 --> 00:02:46,550
\h the dark matter and gas have been separated -- and you actually can see the concentration of the dark

29
00:02:46,550 --> 00:02:52,230
\h offset from the concentration of the gas. And it's a very visual demonstration that the dark matter

30
00:02:52,230 --> 00:02:57,400
\h is real and it's different from the ordinary material, the baryons, the gas.

31
00:02:57,400 --> 00:03:02,390
\h The mystery deepened once more in August 2007.

32
00:03:02,390 --> 00:03:08,840
\h Chandra and optical telescopes revealed that in the Abell 520 galaxy cluster,

33
00:03:08,840 --> 00:03:13,820
\h dark matter behaved in an opposite manner from the Bullet Cluster.

34
00:03:13,820 --> 00:03:19,640
\h Instead of staying with the galaxies, the dark matter collected in the center of the cluster

35
00:03:19,640 --> 00:03:24,630
\h while the bright galaxies collected outside the core.

36
00:03:24,630 --> 00:03:29,520
\h Undaunted by this new finding, astronomers are not giving up.

37
00:03:29,520 --> 00:03:35,660
\h VIKLINHIN: Also for studying dark matter, it's important because most of the cluster

38
00:03:35,660 --> 00:03:42,550

\h mass turns out to be in the form of dark matter. So, clusters are so big that the composition

39
00:03:42,550 --> 00:03:49,370
\h of the clusters is exactly the same as that of the entire universe.

40
00:03:49,370 --> 00:03:55,120
\h Using valuable tools like Chandra, the best scientific minds are working to reveal what