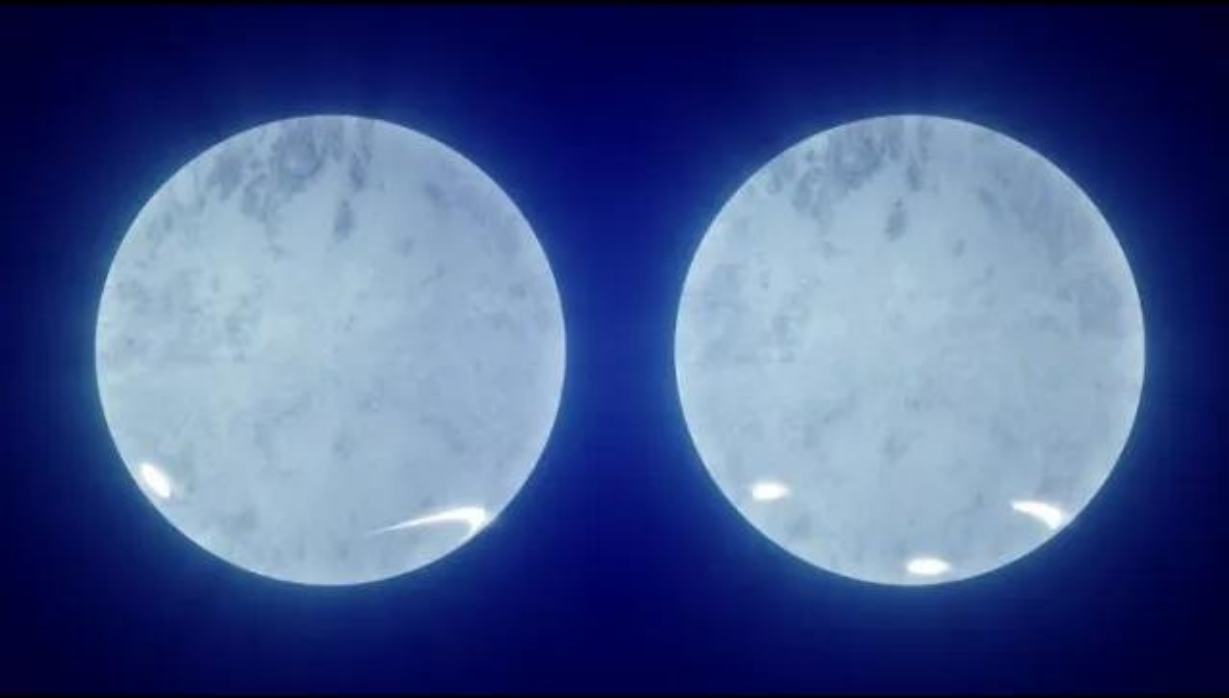

1
00:00:00,000 --> 00:00:04,980
[Music throughout]This is J0030, a type

2
00:00:05,000 --> 00:00:08,980
of dead star called a pulsar, located about 1,100 light-years

3
00:00:09,000 --> 00:00:13,020
away in the constellation Pisces. Observing

4
00:00:13,040 --> 00:00:16,980
J0030 in X-rays, astronomers have now made the most precise

5
00:00:17,000 --> 00:00:20,980
and reliable measurements of any pulsar’s size. And they’ve discovered

6
00:00:21,000 --> 00:00:24,980
that J0030's appearance differs dramatically from textbook depictions.

7
00:00:25,000 --> 00:00:29,020
NASA’s Neutron star Interior

8
00:00:29,040 --> 00:00:32,980
Composition Explorer, or NICER, is a telescope on the International

9
00:00:33,000 --> 00:00:36,980
Space Station. NICER makes extremely detailed X-ray measurements

10
00:00:37,000 --> 00:00:41,020
of neutron stars, and its data provided this unprecedented glimpse

11
00:00:41,040 --> 00:00:44,980
of J0030. A neutron star is the crushed

12
00:00:45,000 --> 00:00:49,020
core of a massive star that exploded in a supernova. Pulsars,

13
00:00:49,040 --> 00:00:53,020

like J0030, are rapidly spinning neutron stars

14
00:00:53,040 --> 00:00:57,020
that sweep beams of energy across our line of sight, much like a lighthouse.

15
00:00:57,040 --> 00:01:00,980
A pulsar is so dense that its gravity

16
00:01:01,000 --> 00:01:05,020
bends the fabric of space-time around it. NICER's precise

17
00:01:05,040 --> 00:01:09,020
X-ray measurements allow scientists to take advantage of this effect

18
00:01:09,040 --> 00:01:12,980
to see light from the far side of the pulsar. This is

19
00:01:13,000 --> 00:01:17,020
a pulsar-sized object about 16 miles across but with much less

20
00:01:17,040 --> 00:01:21,020
mass. We only see light from the side of the object nearest

21
00:01:21,040 --> 00:01:24,980
to Earth. But as its mass increases, the object warps

22
00:01:25,000 --> 00:01:29,020
space-time and acts like a lens to show us light from the far side.

23
00:01:29,040 --> 00:01:33,020
This has the strange effect of making a pulsar look bigger than it really is.

24
00:01:33,040 --> 00:01:36,980
The more mass an object of a given size contains, the more

25
00:01:37,000 --> 00:01:41,020
it distorts space-time and the more we see of its far side.

26
00:01:41,040 --> 00:01:45,020
Textbooks show pulsars with two hot spots on the surface,

27
00:01:45,040 --> 00:01:49,020
directly opposite each other at the magnetic poles.

28
00:01:49,040 --> 00:01:53,020
As the pulsar spins, the spots come in and out of view, creating regular

29
00:01:53,040 --> 00:01:57,020
changes in its X-ray brightness. If the pulsar’s mass is

30
00:01:57,040 --> 00:02:00,980
low, the spots disappear when they rotate to the far side.

31
00:02:01,000 --> 00:02:05,020
But if the mass is high enough, the hot spots may never completely disappear.

32
00:02:05,040 --> 00:02:09,020
Using NICER data, two teams

33
00:02:09,040 --> 00:02:13,020
of scientists examined different models for the shapes, and even the number,

34
00:02:13,040 --> 00:02:16,980
of hot spots on J0030. Both

35
00:02:17,000 --> 00:02:21,020
arrived at the same conclusion — the pulsar is around 16 miles across

36
00:02:21,040 --> 00:02:24,980
and about 1.4 times the Sun’s mass.

37
00:02:25,000 --> 00:02:29,020
This represents the most precise measurement yet of a pulsar’s size,

38
00:02:29,040 --> 00:02:32,980

with an uncertainty of less than 10%. The spots themselves

39
00:02:33,000 --> 00:02:36,980
don’t match the textbook image, though. From Earth, we look down onto

40
00:02:37,000 --> 00:02:40,980
J0030’s northern hemisphere. Both teams say there are no

41
00:02:41,000 --> 00:02:44,980
spots there at all. Contrary to the simple magnetic dipole model,

42
00:02:45,000 --> 00:02:48,980
all the spots appear in the southern hemisphere and are not necessarily

43
00:02:49,000 --> 00:02:53,020
in shapes we might expect. One team, led by researchers

44
00:02:53,040 --> 00:02:56,980
at the University of Amsterdam, suggests J0030

45
00:02:57,000 --> 00:03:00,980
has one small circular spot and another long, crescent-shaped one.

46
00:03:01,000 --> 00:03:05,020
The other team, led by researchers at the Universities of

47
00:03:05,040 --> 00:03:09,020
Maryland and Illinois, finds two oval hot spots.

48
00:03:09,040 --> 00:03:13,020
Their sizes, shapes and locations closely match those derived from

49
00:03:13,040 --> 00:03:17,020
the other model. However, the Maryland-led team also finds

50
00:03:17,040 --> 00:03:21,020
a third, cooler spot located slightly askew

51
00:03:21,040 --> 00:03:25,020
of the pulsar’s south rotational pole, just at the edge of our view of the pulsar.

52
00:03:25,040 --> 00:03:29,020
Scientists are still trying to determine why

53
00:03:29,040 --> 00:03:33,020
J0030’s spots take on these shapes and arrangements, but for now it’s

54
00:03:33,040 --> 00:03:37,020
clear that pulsar magnetic fields are more complex than originally

55
00:03:37,040 --> 00:03:41,020
assumed. NICER’s measurements of

56
00:03:41,040 --> 00:03:45,020
J0030 have opened a new chapter in our understanding of neutron

57
00:03:45,040 --> 00:03:48,980
stars. As it continues to study other pulsars,

58
00:03:49,000 --> 00:03:52,980
we’ll learn even more about the common characteristics — and

59
00:03:53,000 --> 00:03:57,020
individual quirks — of these incredible objects.

60
00:04:05,020 --> 00:04:01,020
[Pulsar grid animations by Sharon Morsink, University of Alberta. Pulsar magnetosphere animation by Alice Ha