11.0: Black Holes Introduction

Video Transcript

ESOcast

[Narrator] In an unprecedented 16 year long study using several of ESO's flagship telescopes, astronomers have produced the most detailed view ever of the surroundings of the monster lurking at our galaxy's heart: a supermassive black hole. The research has unraveled the hidden secrets of this tumultuous region by mapping the orbits of almost 30 stars.

[Narrator] This is the ESOcast, cutting edge science and life behind the scenes of ESO, the European Southern Observatory, exploring the far reaches of the universe with our host Dr. J., AKA Dr. Joe Liske.

[Dr. J.] Hello and welcome to the second episode of the ESOcast. Today we have a very cool piece of science for you. A team of German astronomers, with characteristic precision and patience, have spent 16 years mapping out the motions of 28 stars orbiting the very center of our Milky Way galaxy. Now, astronomers have believed for quite a while that the center of our galaxy is the site of a supermassive black hole. Black holes are a consequence of general relativity. They are objects that are so dense and whose gravity is so strong that not even light can escape them. These observations that we're going to how you today are the best evidence yet that black holes are not just theoretical constructs but actually do exist in reality. This is truly a milestone result.

[Narrator] Observers under dark skies far from the bright city lights can marvel at the splendor of the Milky Way arching in an imposing band across the sky. Zooming in towards the center of our galaxy, about 25,000 light-year away, you can see that it is composed f myriads of stars. This is a pretty impressive sight, but much is hidden from view by interstellar dust and astronomers need to look using a different wavelength, the infrared, that can penetrate the dust clouds. With large telescopes, astronomers can then see in detail the swarm of stars circling the supermassive black hole in the same way that the Earth orbits the Sun. The galactic center harbors the closest supermassive black hole known and the one that is also the largest in terms of its angular diameter on the sky making it the best choice for a detailed study of black holes.

[Dr. J.] So what this team did was that, at various points of the past 16 years, they kept taking images of the very central region of the Milky Way. Now, from these images they were able to map out the motions of a total of 28 stars, and what these motions showed was that these stars aren't just moving about randomly, but that they are clearly orbiting a very massive central object - and the point is that this central object is completely unseen. Now, from the motions it's also possible to deduce the mass of the central object. It came out to be a little over 4 million times the mass of the Sun. Now, what's more, that enormous mass has to fit into a tiny little volume, and so one cannot escape the conclusion that the central object really is a black hole.

[Narrator] The observing campaign started with observations made in 1992 with a SHARP camera attached to ESO's 3.5 meter New Technology Telescope, NTT, housed at the La Silla observatory in Chile. More observations have subsequently been made

in the last few years using two instruments mounted on ESO's 8.2 meter Very Large Telescope, VLT. Over the 16 years of this study, ESO's telescopes have stared at this one region for 50 full nights.

[Dr. J.] This new research marks the first time that so many of these central stars have had their orbits determined so precisely. The data also revealed a lot about the characteristics of these stars and how they must have formed. For one of the stars, the astronomers were even able to follow it for a complete orbit. The star approached the central black hole to within just one light-day – that's just five times the distance between Neptune and the Sun. Professor Reinhard Genzel from the Max Planck Institute for Extraterrestrial Physics in Germany is the leader of the team that made the discovery. Reinhard, why is it so important to study the center of the Milky Way?

[Prof. Genzel] Well you see, the Milky Way center is one of the most important laboratories we have to study, in very great detail, what's happening in the centers of galaxies - in much more detail than we can ever hope to do in all other galaxies. Yet, here we are: we can study whether there's a central black hole, what happens around it, and so forth; all very general issues which we would like to explore and which we cannot really study that much in detail in other galactic nuclei.
[Dr. J.] Doctor Stefan Gillessen is the first author of the paper reporting the study. So Stefan, tell us: what's the most important result you obtained?

[Dr. Gillessen] The most important result of our research really is that we now have empirical evidence for the existence of a massive black hole in the center of our Milky Way. The mass of this black hole is around 4 million solar masses and we know the mass at the percent level.

[Dr. J.] This is, of course, and amazing result. But the team doesn't plan to stop here. Now, in the past they've used the novel technique of adaptive optics to remove the blurring effects of the atmosphere. In the future, they plan to do even better, and to get even higher resolution images by using another new technique called interferometry. This is where you combine the light from two or more of the VLT's Unit Telescopes together. So Reinhard, what's the next step?

[Prof. Genzel] Well, you see, at this point we really are fairly sure that there is a massive black hole at the center of our Milky Way, and the next thing we want to actually play with it, play with it in the sense that we want to use it as a tool to test whether general relativity, the theory of Einstein, is actually wrong or right.

[Dr. J.] Wow, playing with a black hole to test relativity – that's pretty cool stuff. I'm Dr. J., signing off for the ESOcast. Join me again next time for another cosmic adventure.

Black holes have captivated the public imagination like no other astronomical object. Most of us have seen them depicted in movies, on television and in books. Unfortunately, the popular treatments given to black holes do not usually do them justice. What's more, they tend to leave people completely misinformed as to their nature. In this chapter we hope to give you a more accurate picture of what black holes are and how they fit into the Cosmos.
