Evidence and theories of supermassive black holes

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Supermassive Black Holes are at the centres of galaxies: The evidence for their existence and the theories for their formation and effect on the evolution of galaxies.

Supermassive Black Holes are an area of astronomy that have been significantly studied and with thanks to the advance in technology, scientists have managed to better understand how they are formed and the impact they have on the evolution of galaxies. It is first wise to look at the definition of what a black hole is compared to a Supermassive Black Holes. NASA's World Book (2004) defines a black hole as " a region of space whose gravitational force is so strong that nothing can escape from it." Scientists believe that a Supermassive Black Hole have the same characteristics as a black hole, with the main difference being, as the name Supermassive suggests, the size of the black hole. Many astronomers and scientists believe that a Supermassive Black Hole is the largest variety of black hole within a galaxy. What most have also believed is that as well as being the largest type of black hole, these Supermassive Black Holes can be found at the centre of galaxies. This essay will therefore look at the evidence for the existence of these Supermassive Black Holes, as well as theories for their formation and the effect they have on the evolution of galaxies.

Firstly we should look at the evidence that suggests these Supermassive Black Holes exist at the centre of galaxies. Astronomers and scientists at first found it difficult to prove that black holes do exist in our galaxies. In 1916, Albert Einstein, one of the most well known physicists created his General Relativity theory. Although his theory was first published in 1916, it could be seen to indicate there could be objects in space in which his theory applies to. The theory of Einstein would suggest that there could be an object that

alters both space and time, so much so that not even light can escape from it. This is what many modern scientists believe that a black hole is. Many scientists believe that the gravitational force that comes from these black holes is far too strong for anything to escape its pull, including light, which would then explain how these black holes appear invisible. To help prove the existence of this invisible force therefore, Theodore P. Snow (1991, p. 514) suggests that " the best chance of detecting a black hole…is to look for an invisible object whose mass is too great to be anything else." Scientists have therefore looked at the movement of stars around this invisible object in several different galaxies, and thanks to these measurements in 1914 the Hubble Space Telescope (2003, p. 198) managed to determine the mass of the object to be several million times the size of the sun was present in the stars orbit. Scientists and astronomers believe that the only object that could have this effect on the stars orbit and have as high a mass would have to be a Supermassive Black Hole. The Telegraph in December 2008, reported that a group of scientists had spent the last 16 years studying whether there was a Supermassive Black Hole at the centre of our galaxy, in the Milky Way. As before they studied the stars orbit circling the invisible object and found that the mass seems to be about four millions times the size of the sun. This would therefore suggest that Supermassive Black Holes are at the centre of galaxies, including our own. Astronomers and Scientists therefore believe that if you measure the mass of a dark object and that it has a high mass in a small area of space it is most probably a Supermassive Black Hole.

Once scientists and astronomers had seemed to provide substantial evidence to the existence of these Supermassive Black Holes, they did not

stop their research in this area. Many sceptics believed that if these objects existed in our galaxy how did they appear? Thus scientists and astronomers continued to research Supermassive Black Holes and how they have been formed. Kuhn and Koupelis (2001, p. 496) state that “ astronomers predicted the existence of black holes in the 1930s when they realized that a star’s mass may cause it to collapse beyond neutron degeneracy.” This is an explanation for how black holes are formed, however the majority of astronomers and scientists believe there could be more than one explanation for how Supermassive Black Holes are formed. One model that scientists believe could explain the formation of these objects in our galaxy is looking at the early years of the stars. This model looks at how the first stars were formed without a suitable make-up which could have resulted in them leaving behind what is known as “ black hole seeds”. The idea that black holes have been formed by these seeds has been studied in recent years with Volonteri, Haardt & Madau (2003) believed that these black holes may have stemmed from “ seeds” of the early stars, meaning Supermassive Black Holes could be millions of years old, which could explain how they are at the centre of our galaxies. Another model that looks to describe the formation of these Supermassive Black Holes is the idea that they are in fact formed due to the collapse of a large gas clouds. These large gas clouds would collapse into a rotating neutron star of an extremely high mass, this star would be unstable due it not containing the correct electron make-up and instead of a supernova explosion it would result in a Supermassive Black Hole as being its only remaining by-product. Haehnelt & Rees (1993) studied this idea that the Supermassive Black Holes were formed due to the collapse of large gas clouds and have suggested that this model helps give a more

modern understanding of how black holes are formed. Another model which has been suggested by a minority of researchers is the idea that Supermassive Black Holes are a by-product of the beginning of the galaxy, the Big Bang. These scientists believe that after the Big Bang, the pressure of the newly formed galaxy would be extremely high, so much so, that it could have resulted in areas of high density that would have formed black holes. They suggest that many of these black holes would not have lasted a long period of time as the galaxy was expanding, however some may still exist to this present day. According to J. PLuminet (1992, p. 177) if this is the case, the galaxy would expand around the black hole leaving it and the centre of the galaxy.

With researchers now able to provide evidence that Supermassive Black Holes do exist at the centre of our galaxies and being able to give various substantial evidence on the formation of these black holes, astronomers and scientists have also looked to explain how they have an effect on the evolution of galaxies. As we have seen, many researchers believe that there are Supermassive Black Holes at the centre of the galaxies. Researchers believe that roughly ten percent of the black holes contain high levels of ionised gas, which is released in opposite directions of the black hole. This is most likely to be released as kinetic energy. Astronomers believe that this would have an effect on how stars behave and play a vital role in the evolution of galaxies within the universe. For many years astronomers and scientists have been able to find a correlation between the mass of the Supermassive Black Holes and the galaxy it inhabits. In other words, many researchers believe that the size of the black hole does have an effect on the

mass of that galaxy. More recently however researchers have managed to acquire some knowledge on how else a Supermassive Black Hole has an impact on its galaxy. Scientists have studied the spin of the black holes, as they believe this could result in the ionised gas being released from the black hole, which would then in turn control the growth of the galaxy it is at the centre of. Another way that these Supermassive Black Holes could have an impact on the evolution of galaxies could be as a result of two black holes colliding. Researchers have recently discovered what will happen when two Supermassive Black Holes “ collide” with one another. The gravitational attraction between the two is believed to upset the stars positions surrounding the galaxies centre, but many researchers did not know whether the two would attract together to form one large supermassive black hole or whether they would repel from one another? Scientists have recently been able to answer this thanks to a collision that occurred between a large and small black hole. The results of the collision were as expected with the stars surrounding the centre being upset and altered. The question to whether they would form a larger black hole or repel was also answered, as the two became closer they repel and eject the black hole from its galaxy, sending it at high speeds across space surviving on its accretion disk alone. According to Govert Schilling (2002, p. 233) many researchers believe that thanks to this phenomenon that took place, they may be able to further explain formation of galaxies and their black holes, with further research and more advances in technology scientists and astronomers will continue to study Supermassive Black Holes.

As we have seen from the proposed research put forward by various astronomers and scientists, it seems more than likely that Supermassive Black Holes do exist at the centre of our galaxies. Thanks to the research, they have helped in the understanding on how they exist, as being large invisible objects with an extremely large mass and large gravitational pull that is at the centre of every galaxy. As well as this, astronomers and scientists have also been able to explain how these objects could have formed in our galaxy, by looking at different models which include dying stars being turned into black holes millions of years ago, to models which suggest they are formed due to collapsing dense gas clouds. We have also seen researchers look at the impact such objects have had in our galaxies, and seen suggestions that these Supermassive Black Holes helped to create the way a galaxy looks, such as its stars positions and the galaxies mass. With further research and more advances in technology, the future could see more results into this area of astronomy, with researchers looking at a clearer definition to how these Supermassive Black Holes are formed and what effect they have on the evolution of the galaxies they inhabit.

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