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Design And Implementation of Analyses on Black Hole Growth across Cosmic Time and Its Relation to Galaxy Evolution

Dr. Geeta Khoobchandani[1], Anendu Haldar[2]
[1]Research Guide, Dept. of Physics, Sri Satya Sai University of Technology and Medical Sciences, Sehore Bhopal-Indore Road, Madhya Pradesh, India.
[2]Research Scholar, Dept. of Physics, Sri Satya Sai University of Technology and Medical Sciences, Sehore Bhopal-Indore Road, Madhya Pradesh, India.

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Abstract
We use the most up-to-date hydrodynamic models of how cosmic structures form to study the relationship between how galaxies grow and change and how the supermassive black holes in them change over time. Starting right from the beginning conditions that make sense for cosmology, we follow the dynamics of dark matter, radiative gas cooling, and star formation, as well as the growth of BHs and the feedback mechanisms that go with them. This is something that has never been done before. The way we model the physics of black holes is based on the work we did simulating the collisions of galaxies that were on their own. This project has been going on for a while. At low redshifts, the ratio of black hole mass density to stellar mass density doesn't change much, but the black hole accretion rate density reaches its peak at a lower redshift and changes more than the star formation rate density at high redshift. We find that there are strong links between the masses of black holes and the features of the star systems around them. These correlations match up well with the local relationships that have been reported, but they also suggest (depending on the mass range) that both the normalisation and the slope change slightly with redshift. Due to long periods of exponential growth in places that fall apart quickly and show strong gas imports, our models also make huge black holes at high redshift. These places get a lot of gas from other places. But these early supermassive BH systems aren't necessarily the most massive ones that exist now. This is because quasars that form later tend to grow and become more massive than the early ones.
Keywords: black hole growth, cosmic time , galaxy evolution.

Introduction

There are two primary categories of systems that are assumed to be the origin of astrophysical black holes in our immediate universe: X-ray binaries and active galactic nuclei (AGN). It is possible to arrive at an estimate of their mass function by adding up the estimated masses of each of their individual masses (either directly through dynamical measurements or indirectly through phenomenological relations). It would indicate that there is not a significant population of black holes located in the middle of these two extremes (i.e., between 105M and 1M). The apparent peak in the number of supermassive black holes in this distribution can be explained by the cosmic expansion of structures as well as the evolution of mass inflow into (and inside) the nuclear regions of galaxies. It's possible that the mergers that take place in these nuclear zones are what regulated such a massive influx of people. On the other hand, the precise modelling of the height, width, and mass scale of the low-mass peak is made possible by the theoretical modelling of stellar (and binary) evolution and the physical mechanisms that produce supernovae and gamma-ray bursts. These are the two types of processes that are currently being studied. The reason for this is due to the fact that the low-mass peak is the end product of the evolution of stars as well as the physical processes that produce supernovae and gamma-ray bursts. Our primary objective is to determine whether or if the known population of supermassive black holes in galactic nuclei can be used to models of their cosmic growth in order to impose constraints on such models. We have high hopes that one day we will not only be able to explain how these items come into being, but also the primary stages of their development that have been witnessed across the entire population of AGN. In contrast to galaxies, which are constantly undergoing morphological and photometric changes, there is a significant correlation between the shifting mass functions of the various SMBH and the distribution of star formation. This is the case despite the fact that galaxies are constantly undergoing change. It's likely that these changes are reflected in alterations in the distribution of galaxies, but it's not certain. Mass and spin are the only two properties that can be used to characterise black holes. This is all that's needed to do so. Analytic equations determine how the evolution of black holes is controlled throughout time as a function of the rate at which they accrete mass. If the stages of their growth are thoroughly sampled in observations, then it is possible to recreate the full cosmic evolution of every "seed" black hole population and directly compare its endpoint to any local observation. This is only possible if the stages of their growth are observed in sufficient detail. The history of black holes throughout the cosmos may now be pieced together thanks to this information. Because of this, it is more likely that a diverse range of AGN searches will be conducted (surveys). If we gain a deeper understanding of the various physical and electromagnetic processes that take place in the region surrounding accreting black holes, we will be able to raise the bar for the required level of completeness that can be attained through practical application. In order to make sense of the findings of AGN surveys, which are essential to any conversation about the development of supermassive black holes, it is essential to have a solid understanding of the underlying physics that underpins the phenomenology of AGN.

Related work

The term "Active Galactic Nuclei" refers to the wide variety of phenomena that are brought about by the accretion of matter onto the supermassive black holes that reside in the centres of galaxies. When it comes to exceptionally luminous objects such as Quasars (QSO), their luminosity can come close to approaching the Eddington luminosity for black holes of a few billion solar masses1, which enables them to be seen at the maximum redshift that has been examined to date ($z > 7$). Sgr A* in the nucleus of the Milky Way is an example of this phenomenon; it radiates at a brightness that is less than a billionth of the Eddington brightness of the 6:4 M BH that it harbours, proving that enormous black holes in galactic cores can be incredibly dark. Because the masses of SMBH black holes and the accretion rates of these objects can span such a wide range, the observable phenomenology of these things can be extremely variable and intricate. The unique complexity and multi-scale structure of the problem make it difficult to observe and characterise the multiple accretion components. This makes it challenging to study accretion. This amount of complexity has a major effect on our ability to retrieve the underlying physics from observations made at various wavelengths, whether those observations are made of individual objects or of enormous samples, and they frequently result in serious observational biases. It is sufficient to make simple estimates in the order of magnitude. As is the case with all accreting black holes, the vast majority of the energy, whether it be radiant or kinetic, that is released by an accreting galactic nucleus occurs on scales of only a few Schwarzschild radii. The properties of the interstellar medium of the galaxy have an effect on the mass inflow rate around 105 times further out, at a point where the gravitational impact of the central black hole begins to dominate the dynamics of the intergalactic gas (the so-called Bondi radius) (accretion rate). On the parsec scale and outside the sublimation radius, a dusty, large-scaleheight, possibly clumpy medium obscures the view of the inner engine that is crucially determining the observational properties of the AGN; on the same scale, powerful star formation may be triggered by the self-gravitational instability. The optically prominent broad permitted atomic emission lines of unobscured QSOs are produced at 0.1-1 pc (Broad Line Region, BLR). Last but not least, AGN-generated outflows (either winds or relativistic jets) are reported on galaxy scales and above (from a few to a few hundreds kpc), frequently transporting considerable quantities of energy that have the potential to significantly affect the (thermo-)dynamical state of the interstellar and intergalactic medium. When trying to examine the cosmic evolution of AGN, which involves witnessing and measuring the signals of accretion onto nuclear SMBH within distant galaxies, it is nearly impossible to obtain the necessary high spatial resolution across the electromagnetic spectrum. This makes it nearly impossible to obtain the required high spatial resolution. However, due to the fact that the amount of matter captured within the Bondi radius can vary enormously depending on the specific physical condition of the nuclear region of a galaxy at different stages of its evolution, growing black holes will always display a large range of "contrast" with the galaxies in which they are hosted. This is because the amount of matter captured within the Bondi radius can vary enormously depending on the specific physical condition of the nuclear region of a galaxy. There is evidence to suggest that ((Volonteri, M., et al., 2018) In this study, we investigate the black hole (BH) population in the Horizon-AGN large-volume cosmic hydrodynamical simulation. This simulation uses statistical modelling to recreate the process of gas accretion onto BHs. It also monitors the energy that is deposited into their surroundings and, as a consequence of this, it analyses how the surrounding medium influences the growth of BHs. In addition to additional observable limitations, the redshift evolution of the black hole mass density and the black hole mass function can both be recreated by the synthetic BHs. A strong self-regulation through active galactic nuclei feedback (AGN feedback), a modest supernova feedback, and unresolved internal processes are the products that provide a tight BH-galaxy mass correlation. The process of tidal stripping starts at z 2, which results in the production of a small population of BHs that are excessively large for their position in the halo. The percentage of galaxies that include either a black hole or an active galactic nucleus rises in direct proportion to the star mass of the galaxy. If obscuration is not taken into account, multi-wavelength studies and single-wavelength studies do not agree on the AGN fraction as well as they would otherwise.

Proposed methodology

Galaxy groups, galaxy clusters, and large galaxies all have gas that is very hot and gives off a lot of X-rays. The "cooling flow" problem is the question of why this gas doesn't cool down quickly. A lot of research on this topic has been done in galaxy clusters, which have very strict rules about where and how you can look at things. There are two types of X-ray groups and clusters: ones where the X-ray surface brightness rises more slowly toward the centre, like 90% of the X-ray-selected groups and clusters with halo mass (Mhalo) 1014 solar masses and 50% of the clusters with Mhalo 1014 solar masses63, and ones where the surface brightness rises more steeply toward the centre, like 90% of the X-ray-selected groups and clusters with halo mass (M The formula n 2 can be used to figure out how much light a gas gives off per unit of volume, where n is the density of the gas and is the cooling function. How well the gas can cool down depends on both how hot it is (T) and what chemicals are in it. X-ray spectroscopy has shown that the temperature T and the temperature of the virus Tvir are always on the same scale. The temperature at which a gas is in balance with gravity is called its virial temperature, or Tvir. So, the way to tell the difference between the two kinds of cluster is by how dense they are. The gas in the first type of cluster has a high central density and gives off heat at a rate of tcool = (3/2)kT/n2, where k is the Boltzmann constant. In most of the cluster's core, this timescale is usually much shorter than a gigayear. These groups of stars are called "cool-core" clusters because the temperature drops as you get closer to the centre of the group. But cool-core clusters are not true "cold core" clusters because the temperature only drops by a factor of three as you get closer to the centre of the cluster. If the soft X-ray line, Fe XVII, is not there or is not strong enough, the amount of heat lost to X-rays shows that ten times less gas cools by radiating below this temperature than we would expect. This is because the amount of heat lost to X-rays is directly related to how much heat is lost. Even though the gas gives off heat, it must be possible to add more energy to make up for the fact that it doesn't get cooler. The relationship between X-ray brightness (also called LX) and X-ray temperature (also called X-ray temperature) is another piece of evidence (T). LX = n 2 Tvir 1/2 rhalo 3 gives the X-ray luminosity, where rhalo is the radius of the halo and Tvir = Mhalo/rhalo. At a temperature of 3 keV, where bremsstrahlung is the main source of radiation, this equation is correct. If n scaled with the halo density, which is proportional to the average density of the Universe, then all clusters should have the same value for n, and this equation says that LX Tvir 2 will be the case. Spectroscopy shows that T is greater than Tvir, but the data show something completely different. LX Tvir , and this line gets even steeper when Tvir keV , because n goes down at low masses. However, there is a lot of change in this relationship. At a given temperature, a higher entropy is shown by a lower density. This can be calculated with the formula K = kT/n 2/3. The only way to make the entropy of something go up is to heat it. At a distance of 0.1 rhalo, clusters usually have entropy excesses of K 100 keV cm 2. Smaller clusters are more likely to be hurt by these excesses because their entropies are lower in absolute terms but higher than what theory says they should be. This problem shows up in both cool-core and non-cool-core clusters, and it affects a large part of the medium between clusters. It's possible that the quasar winds that are thought to stop star formation in the progenitors of giant ellipticals could solve this entropy problem by preheating the intergalactic gas that will become the intracluster medium. However, they can't solve the cooling-flow problem in the centre of cool-core clusters. Since these systems cool down so quickly, mec2, where me is the mass of an electron, can be found. If you look at the size of the cavities (Vcav) and the pressure of the medium inside the cluster, you can figure out how much work the jets had to do to make the cavities (pICM). The results of this experiment and the pICMVcav study on "quasistatic," or very slow, inflation, are the same. But the shape of cavities can change because of the Rayleigh-Taylor instability.

Results analysis

How Black Holes Have Changed the Way Galaxies Have Grown In both galaxy clusters and huge elliptical galaxies, the cooling process limits the amount of gas that can turn into stars. From the number of stars, chemical abundances, and shapes of huge elliptical galaxies, it is clear that not much gas has fallen to the galactic core and made stars in the billions of years since these galaxies formed. The fact that there aren't many stars in these galaxies makes it easy to come to this conclusion. Cooling flow is a bigger problem in galaxies than in clusters because the deaths of massive stars return 30–40% of the total mass of all stars to the interstellar medium over the course of the Universe's lifetime. Even if you take into account the hot gas inside the halo, this is still true. If even a small amount of the gas from big stars that are getting close to the end of their lives is accreted, the black holes that form would have a mass that is much higher than what has been seen. When trying to use the same reasoning for clusters and galaxies, the fact that galactic jets tend to be collimated makes it hard. The entropy shelf that surrounds NGC shows that heating has only been important at a distance of 2 kpc. This means that they must be digging through the gas around them and dumping most of their energy outside of the galaxies where they are made. Even though it has jets, the central galaxy in the Perseus cluster seems to be part of the group of cD galaxies that are blue. Because the air pressure is lower in galaxies that are not at the centre of a cluster, it is much harder for them to keep their jets under control. In space, a jet's power goes to waste because it doesn't have a surface to focus on. Still, there are counterexamples, like Centaurus A, M, and NGC 3801. In these cases, the jets have caused the gas that is being heated to move around on a galactic scale. Also, a jet can continue to send some of its energy into the interstellar medium even after it has left the galaxy where it was born. For instance, if M's jet has knots, this could mean that the object in question has been interacting with the medium between the stars. Despite this problem, it is interesting to note that the time-averaged jet power is the same as the gas X-ray brightness over two orders of magnitude in galaxy mass, and that the fraction of ellipticals that host a radio source scales with MBH in the same way that the estimated gas cooling rate87 does. Both of these results fit with the idea that the gas cools at a rate that is proportional to the galaxy's size. If jets can't keep the gas around them at the same temperature by radiatively connecting to it, then cooling will trigger an optical AGN, which will turn back on the heat. Gravitational heating from the work done by falling clumps as they fall deep into galaxies heats the gas, and type I supernovae in small elliptical galaxies also heat the gas. On the other hand, the rate of radiative loss can't affect these energy sources in any way. If they heat the gas at a slower rate than it is cooling, the gas will gradually cool down. If they heat it at a faster rate than it is cooling, an outflow will happen. But measurements with X-rays show that the gas in giant elliptical galaxies is in hydrostatic equilibrium. On the other hand, we often can't find any X-ray-emitting gas in lower-mass ellipticals, where the X-rays come from separate sources. Heat generation and gravitational strain I supernovae may help relieve pressure on AGNs because their contribution to the overall heating rate is just the difference between what is needed to keep the gas in equilibrium and what is given by these other sources. This is because their contribution to the overall rate of heating is just the difference between what is needed to keep gas balance and what these other sources provide.

Conclusion

But we still don't know much about how power gets from active galactic nuclei (AGN) to the surrounding gas and how expanding jets and rising bubbles cause hydrodynamic disturbances that heat up. The strongest evidence for black hole feedback comes from groups of galaxies. It is possible for cosmic rays, turbulent viscosity, standard viscosity, the stretching and tearing of magnetic field lines, and/or the stretching and tearing of magnetic field lines to heat and/or lift the intracluster medium. At least in a first approximation of the idea, the idea that black holes can change their accretion rates on their own to stop cooling is true. But there is evidence that some of the gas in clusters does cool and flow into the cores of galaxies, though at a rate that is orders of magnitude slower than what models of pure cooling flow predict. In 25% of clusters, this gas starts the process of making stars, which leads to the formation of cD blue-core galaxies86. Theoretical models and computer simulations have a hard time explaining quantitatively why real clusters are different from a "ideal" feedback loop that stops cooling and star formation 100% of the time. This is a problem for both of these areas. We know a lot less about how radio galaxies interact with their own interstellar medium than we do about how they interact with the medium between clusters. We now understand a lot more about how radiative feedback affects the medium between the stars. So, the main question that hasn't been answered to everyone's satisfaction is whether or not radiative feedback can provide the energy needed for the "maintenance" of individual ellipticals without going over the limits set by observations on the percentage of ellipticals that have an active galactic nucleus (AGN). The most important question that hasn't been answered is how quasar winds stop stars from forming. This is why spectroscopic estimates of wind masses are often wrong by more than an order of magnitude. We need to improve our understanding of the masses, length scales, and temperature structure of the winds across all redshifts. This is the most important challenge for observing. Also, there needs to be a better understanding of what kinds of things galaxies are like in the area where the blue and red populations meet. In conclusion, we'd like to point out that computer simulations make it clear that quasars need to be quenched. These simulations are based on theories that aren't very good about how stars form and how the interstellar medium works. Before deciding that quasar feedback is necessary, more research needs to be done on these processes and simulations with a higher resolution need to be done. This is especially true for ellipticals with lower masses, where the rate of star formation slows down over a longer time.

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