ACTIVE GALAXIES

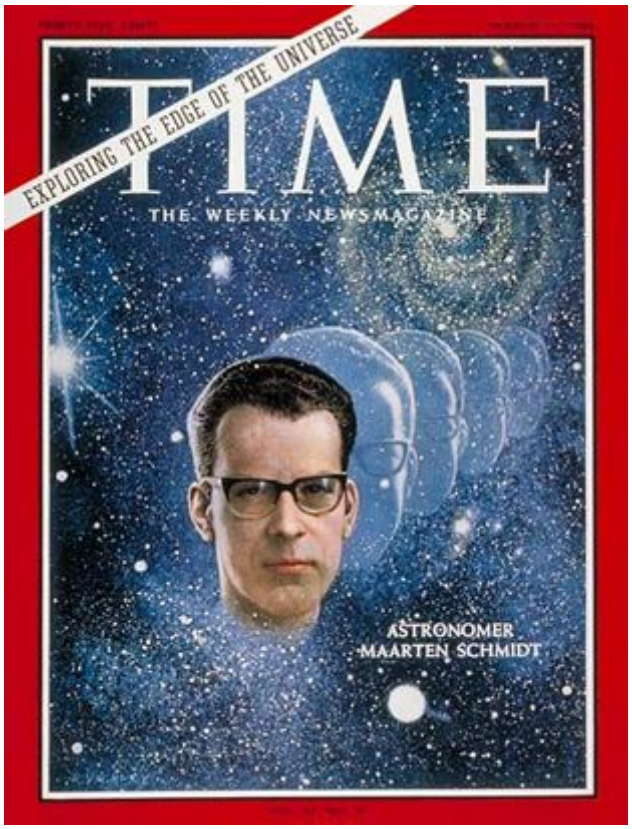
-By Piyush Jindal

Normally galaxy emit light same as the sum of all the stars and gas clouds present in it, further disc and core of such galaxy have roughly the same brightness however there are some galaxy which are very different from normal galaxy as they have magnificently bright core or nucleus which radiates tremendous amount of radiation in nearly entire spectrum ranging from radio to X-rays and even gamma rays and are known as active galaxy. These galaxies hosts active galactic nucleus, abbreviated as AGN at centre which lights up its core or central part.

This subject began when Herber Curtis first noticed jets of particle and rays coming out of M87 in 1918. Further progress came with the discovery of strong and broad emission lines in the spectrum of some luminous galaxy by Carl Seyfert in 1943 which are now known as “Seyfert galaxies”. A major breakthrough came in 1963 with the discovery of high red shift (z=0.158) of 3C273 by Maarten Schmidt which led to the discovery of first quasar. Later this field became hot in field of astrophysics because of its high energy output.

Source: Hubblesite.org (http://hubblesite.org)

M87



Marteen schmith on the cover of time magazine

Observed properties

Active galaxies differ a lot in their properties but they have few general observed properties which are as follows:-

Luminosity

They have broad range of luminosity. At very low luminosity, the distinction between active galaxy and normal galaxy is not much whereas at their peak in luminosity AGNs outshines their host galaxies by factor of 10000 or more.

Strong UV-Optical spectra

Apart from having absorption lines, these galaxies have Strong emission lines even in the ultraviolet bands indicating the presence of very hot excited gases which indicates the presence of high energy source which is exciting atoms of these gases.

Presence of board emission spectra

These galaxies emission spectra are broad indicating the rapid rotation of excited gases and thus presence of strong gravitational field. As we know that spectra of objects receding us are red shifted whereas spectra of objects approaching us is blue shifted and thus rotating objects gives broad spectra as half of it receding from us and other half is approaching towards us.In case of active galaxies accretion disc is responsible for such emission lines.

Emission over broad range of frequency

Unlike stars whose spectra picks up at infra red to ultraviolet range based on Plank's law, active galaxies radiates in broad range from radio to X-rays indicating there is more going on this galaxies than just stars. In fact high UV brightness compared to optical brightness is an efficient method to find Quasars(type of active galaxy). Further they emit good amount of radio and X-rays by process like synchrotron radiation and Compton scattering, therefore non-thermal emission of this rays is another way to find this galaxies.

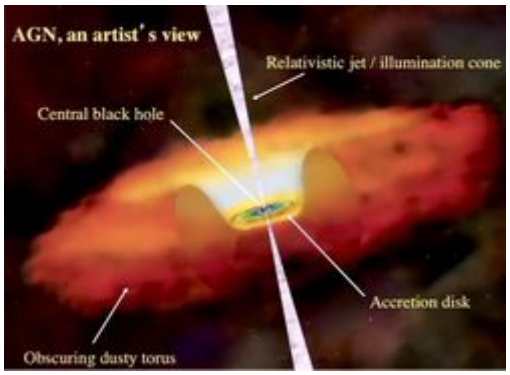
Variability

It was found that emission from some of these galaxies were variable and its amplitude increases and become more rapid with increase of frequencies such that variability in X-ray frequency is in order of days. So for this to happen size of emitting region cannot be more than few light days. Thus it indicates the compact nature of AGN's. The prime cause of such variability is not well understood but few of the proposed reasons include variability in accretion rate, variable obstruction in line of sight and microlensing.

Structure and power source of AGN

Active galactic centre structure can be broadly divide into following parts-

- Central black hole
- Accretion disc
- Obscuring dusty torus
- Relativistic jets



Central black hole

As AGNs have been observed to have high luminosity which is comparable to hundreds and hundreds of normal galaxy put together. Further its variability over short time periods predicts about its compact nature. when both of them put together ,it clearly indicates the presence of super massive black hole as they are the only objects which can produce that much amount of luminosity within a compact region.

Accretion disk

Accretion disc is produced as a result matter falling into central black hole. Falling matter loses is gravitational potential which gets converted into radiation of optical to ultraviolet range. Further this accretion of matter is an efficient energy conversion mechanism in which a large fraction (around 10-20%) of rest mass energy is converted into heat and radiation.

Obscuring dusty torus

Obscuring dusty torus is torus shape mass of dust and gas around central black hole which absorbs the high frequency radiation from accretion disc and emits low frequency radiation mostly in infrared. This accounts for the infrared radiation coming from AGN's.

Source: Hubblesite.org (http://hubblesite.org)

Obscuring Dusk disk around central black hole of NGC 7052

Source: Hubblesite.org (http://hubblesite.org)

Accretion disc around central black hole of NGC 4261

Relativistic Jets

Approximately 10% of active galaxies produces relativistic jets of charge particles which emits radio waves via synchrotron radiation and galaxies with such radio jets are called as radio galaxy. This jets are powered by the rotational energy of black hole just as in case of pulsars. Thus fast revolving black holes produces this radio jets and are termed as radio loud galaxy or radio loud quasars whereas the one without much radio emission are termed as radio quite galaxy or radio quite quasars.

Classification

Active galaxy has a big family as some produce large radio emission while other do not emit that much, some having high luminosity while other don't .In fact they vary so much from each other that they were considered as different objects in past .

Here we will be doing a broad classification as follows-

1. According to strength of radio emission

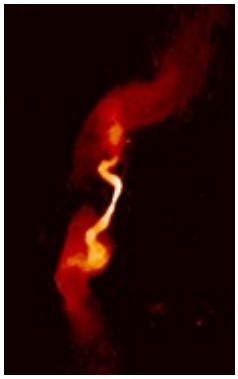
2. According to luminosity

According to strength of radio emission

According to this criteria we can divide active galaxies into two type based on the amount of radio emission. This two types are-

- Radio loud galaxies
- Radio quite galaxies

When radio emission from active galaxies were studied it was observed that this emission have power-law spectra characteristic of synchrotron radiation and as we have discussed that this is produced by jets of relativistic charge particle travelling in the magnetic fields of the AGN. This jets are powered by spin energy of the central black hole thus higher the spin energy more will be the radio emission .Now the prime question would be about what makes black holes attains such high or low angular momentum ? A possible answer is the merger of galaxies which provides this giants their angular momentum. Further as elliptical galaxies are formed by the merger of spiral galaxies therefore we see large radio emission from elliptical active galaxies and low from spiral one.
Thus we can differences between both types in the table below.



Radio Galaxy

Image courtesy of NRAO/AUI (http://images.nrao.edu/AGN/Radio_Galaxies)

Radio Loud	Radio Quite
• Strong radio emission • Presence of high spin black hole • Presence of particle jets • Hosted by elliptical galaxies • Includes radio galaxies ,blazars and radio loud quasars	• Weak radio emission • Presence of low spin black hole • Absence of particle jets • Hosted by spiral galaxies • Includes seyfert galaxies and radio quite quasars

According to luminosity

According luminosity or total amount of energy released by an active galaxies, they can be divided into types-

- Quasar
- Seyfert

Quasar

The first quasar was discovered by Maarten Schmidt in the year 1963.He observed a bright light source object having high red shift of order z=0.158, which was the highest for that time .This high red shift indicated that the source is very far away

from our galaxy and to have large brightness even residing so far pointed out to the tremendous amount of energy generation process from that source .we now know that he was actually looking a quasar, an extreme kind of active galactic nuclei. Thus quasars are a kind of Active galactic nuclei which are having high luminosity and generally with high red shifts.

Seyfert

Seyfert are actually like quasars with less luminosity .Seyfert are spiral galaxies with fluctuating bright core and spectrum of the lights coming from this galaxies are way different than that of normal galaxies on the way that they have excess blue light and strong emission lines as compared to normal galaxies .Seyfert are further classified into two types based on its spectrum or specifically the width of its emission lines.

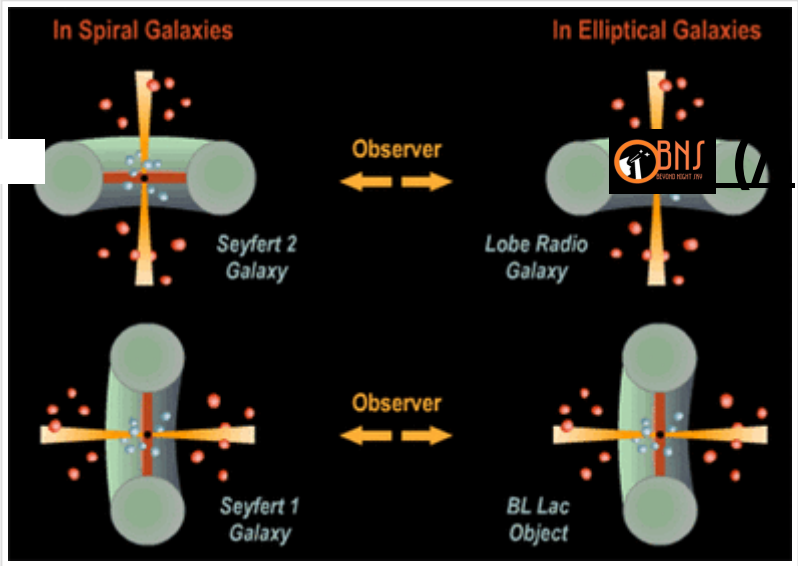
This two types are –

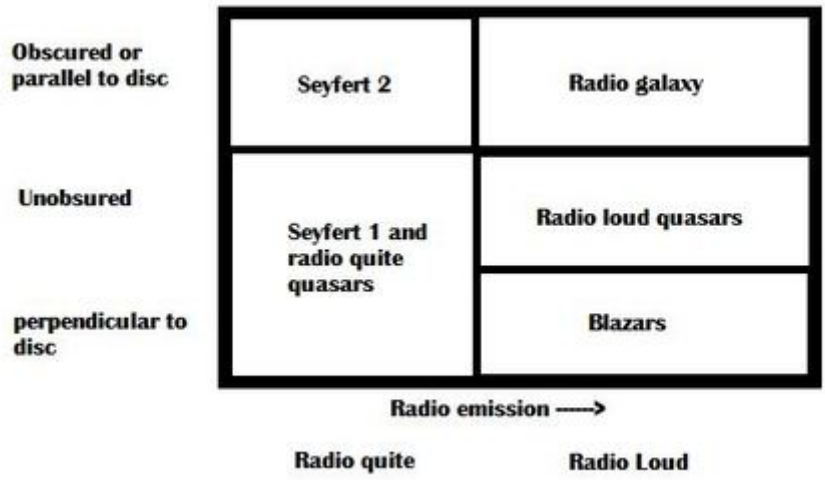
- Seyfert 1
- Seyfert 2

Seyfert1 and seyfert 2 differs mainly in their emission lines which are broad and narrow in case of seyfert 1 and only narrow in case of seyfert 2.The width of spectrum tells us about the speed of rotating source as in case of active galaxies it shows the speed of matter in accretion discs. So the narrow lines means speed is around 400km/s whereas broad lines says speed up to 10000 km/s. further seyfert 1 have stronger UV and X-ray emission as compared to that of seyfert 2.

Unification scheme

As we know that all different types of AGN's are powered by central black hole but what make them look so different? It is actually viewing angle which makes all the difference. When we see radio loud galaxies perpendicular to the jets, we can see its radio jets in two directions of the galaxies and such galaxies are called radio galaxies but if we observe this galaxies such that its dusty torus does not obscures the central radiation then this are called radio quasars and final when we see them such that their jets directly points towards us then they are known blazars or BL Lac objects. Further if we see radio quite galaxies parallel to the disc, we will not be able to receive radiation from central region as dusty torus absorbs most of the radiation and emits mainly in infra-red and such galaxies are known as Seyfert 2 galaxies .Finally when we observe radio quite galaxies perpendicularly we will be able to receive radiation from central region and such galaxies are called Seyfert 1 galaxies , further if energy output of Seyfert 1 galaxy is high they can be termed as radio quite quasars.





Sources

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