LITHUANIAN CENTER OF NON-FORMAL YOUTH EDUCATION

RADIO GALAXIES AT DIFFERENT WAVELENGHTHS

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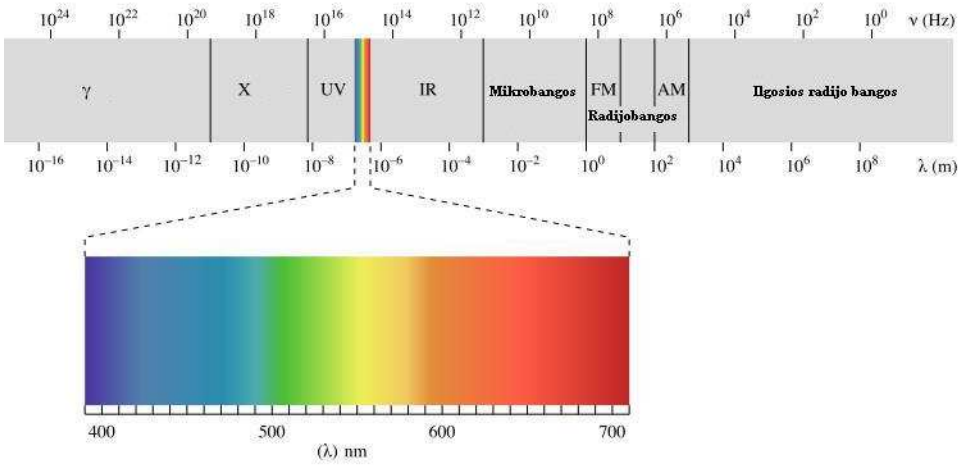
Goals and tasks

The main goal of this work was to make an overview of selected radio galaxies, to describe their nature and to find if there is a correlation between their distances from Earth and the radiation at wavelengths at wich they emit most. In order to reach this goal the data from Chromoscope (http://blog.chromoscope.net/data/) was used.

The definition of visible light

Visible light is electromagnetic radiation that is visible to the human eye, and is responsible for the sense of sight. Light has a dual nature: it can be both defined as an electromagnetic wave and a steam of light particles – photons. Wave can be explained as a disturbance or oscillation that travels through space and matter, accompanied by a transfer of energy. The speed of light in vacuum is the limit – no particles or waves can travel with speed more than 299,792,458 m/s or 1,079,252 848.8 km/h. The speed of light decreases when light travels through different substances: water resists up to 25% of velocity, glass takes 30%. There is no absolute vacuum in space, that‘s why the real light speed is always a little smaller than theoretical. Definition of light speed means a lot for astronomic society – distances sometimes are measured in light years – a distance that takes light a year to pass.

Electromagnetic spectrum



Gamma Rays | X-Rays | UV Rays | Visible light | Infrared | Microwave | Radio Waves

Table 1. Studied radio galaxies. Equatorial coordinates: right ascension α and the declination δ and their distances

Radio galaxy	*A*	*Δ*	*Distance (ly)*
Virgo A	$12^h\ 30^m\ 49.42^s$	+12°23‘ 28.04“	60 billion
Cygnus A	$19^h\ 59^m\ 28.\ 35^s$	+40°44’ 02.09”	600 billion
Centaurus A	$13^h\ 25^m\ 27.6^s$	-43°01’ 09”	11 billion

3C 236	$10^h\ 06^m\ 01.7^s$	+34°54’ 10”	1.3 billion
3C 288	$13^h\ 38^m\ 49.99^s$	+38°51’ 09.5”	8 billion
Perseus A	$03^h\ 19^m\ 48.10^s$	+41°30’ 42”	235billion
3C 401	$19^h\ 40^m\ 25.1^s$	+60°41’ 35”	2348352
3C 388	$18^h\ 42^m\ 35.42^s$	+45°30’ 21.22”	26092
3C 47	$01^h\ 33^m\ 40.43^s$	+20°42’ 10.44”	4,3 billion
3C 449	$22^h\ 29^m\ 07.63^s$	+39°06’ 03.50”	15861
3C 315	15h 11^m 30.83^s	+26° 18’ 39.00”	1956960

Understanding Galaxies and Active Galactic Nucleus

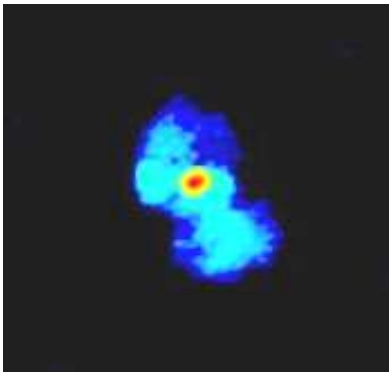
Galaxies are huge systems of stars, often with interstellar gas and dust, bound together by gravity. Galaxies appear in a variety of forms and kinds: spiral, elliptical, irregular and etc, but no matter how it looks, it will always have an active galactic nucleus. It is defined as a central region of a galaxy in which considerable energy is generated by process other than those operating in normal stars. An active nucleus typically shows both continuum and emission-line spectra in the optical and ultraviolet, and may be an infrared, a radio, or an X-ray source.

Radio Galaxies

A galaxy that is an unusually powerful emitter of radio waves is called a radio galaxy. The output of a radio galaxy can be up to 10^38 watts, a million times bigger than a normal galaxy such as the Milky Way. The most powerful and nearest Radio Galaxies are NGC 5128 (Centaurus A), Cygnus A and M87 (Virgo A).

Exploring radio galaxies at different wavelengths

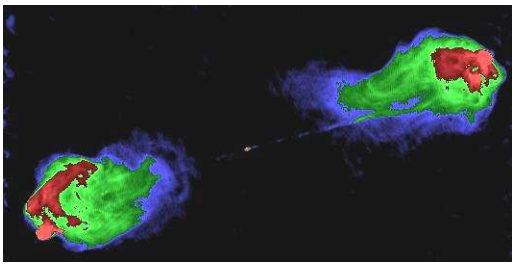
Virgo A radio galaxy



http://www.jb.man.ac.uk/atlas/object/3C274.html

First, I got interested in radio galaxy Virgo A (or 3C 274), which is 60 billion light years away from the Solar System. It is located quite far from the Milky Way. It has a diameter of 120,000 light years. I got curious about intensive X-ray radiation that is emitted from the very centre of 3C 274. The plasma lobes are similar to clouds – they almost cover the galaxy's active core. As we can see it on the snapshot above, one of the lobes is obviously brighter than the other. Low brightness of the second lobe is caused by the first lobe's wide size and higher density. It looks more like a shapeless cloud than a jet or pillar. That's why it is so easy to notice it. Perhaps the difference in the form of lobes appears due to the fact that one of them interfere more with interstellar medium because its gravitation field is bigger and stronger. On infrared photos Virgo A appears as a pale elliptical spot, similar to a bean. Also, this galaxy possesses a clear X-ray halo that is why Chandra X-ray telescope is used for exploring it.

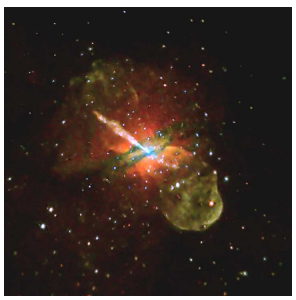
Cygnus A radio galaxy



http://en.wikipedia.org/wiki/Cygnus_A

Other galaxy that is interesting me is the radio galaxy Cygnus A. It is 600 million light-years away from us and its diameter is about 120,000 light years. This galaxy is a very strong source of radio waves. It is on the plane of the Milky Way and is visible only because it is a part of the Cygnus rift huge dark nebulae complex. Dark nebulae absorbs visible light and short-wave radiation (gamma, x-ray), but the long-wave radiation (infrared, microwaves and radio waves) spread well. Therefore, long-wave rays of visible galaxies are clear and well-visible. In microwave mode galaxy appears as a faint speck. Short wave rays of the galaxy are absorbed by dark nebulae. This galactic radio emission power is the same as the calm period of the Sun, so if this galaxy is not obstructed by dark nebulae, it would be one of the most powerful short-wave and long-wave radiation sources. This galaxy has two large plasma lobes, which are much bigger than the galaxy itself. Cygnus A radio galaxy is surrounded by a lot of secrets, mainly due to its high range. At first, astronomers thought that it is a single galaxy, but subsequent data have shown that this may be two colliding galaxies. Now, most astronomers believe that a collision is most likely the reason of this galaxy high activity.

Centaurus A radio galaxy



http://chandra.harvard.edu/photo/2008/cena /

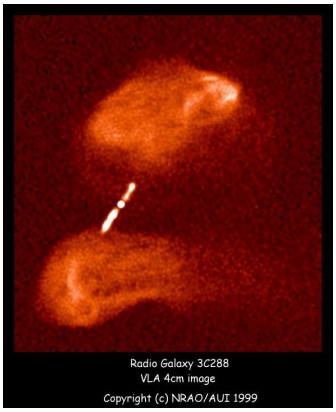
Other chosen galaxy is Centaurus A radio galaxy. It is located about 11 million light years away from the Sun. Since the galaxy is close, it is seen very well in both high-and low-energy rays. They revealed quite a few even from the galactic centre propagated in the plasma jet. Very itemised Chandra X-ray telescope range based images to see the centre of the galaxy and from propagating in the X-ray jet. I noticed that this galaxy jet is more similar to the Virgo A radio galaxy jets, but the galaxy Centaurus A jet plasmid is lower. Most likely, these galaxies are undergoing similar processes. By the way, some astronomers believe that this galaxy is also facing or have faced the lower galaxy. It is judged by a thick disk of dust which surrounds the galaxy. These galaxies jet resemblance to the Virgo A radio galaxy jets proves this assertion.

Galaxy 3C 236

http://en.wikipedia.org/wiki/3C_236

The fourth is my overview of the galaxy 3C 236 radio galaxy. It is one of the largest radio emission sources we know. Its diameter is 4.5 mega parsecs. Galaxy is situated 1.3 billion light years away from the Solar System. It is quite similar to the Milky Way and most visible in radio waves. This galaxy is in the centre of cluster of smaller galaxies. Plasma outflow is a powerful steep-spectrum core. These bright and large spectral outflows nuclei are rare. Their outside structure is often weak and blurry. They usually occur in galaxies that do not have bright nuclei in the hot radiation points. For example, the galaxy 3C 315 is special - it has bright and large hot radiation point and the outflows, which emit especially noticeable radiation. This is visible on the left outflow, which is smaller, but sharper and more focused than the right. Right outflow is much larger, but a little whiter. The second outflow is similar to galaxy's 3C 315.

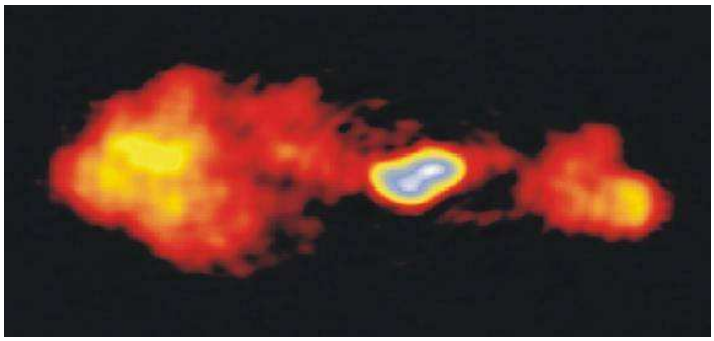
Galaxy 3C 288



http://www.cv.nrao.edu/~abridle/images/3c288x02_large.jpg

Other analysed galaxy is 3C 288. It is 8 billion light years away. The galaxy has two lobes with hotspots of a similar shape. The only difference is that one of them is brighter than the other. This galaxy has two bright X-ray jets, which connect the hotspots with the core. The one that is near the brighter hotspot is visually paler and shorter. It may be caused by the lack of serious barriers, such as interstellar medium, dust or gravity of other space objects. Other jet seems to have more barriers, that's why jet becomes clearer, but shorter. Less material reaches the lobe, so it is a little paler. This galaxy probably has a spherical shape.

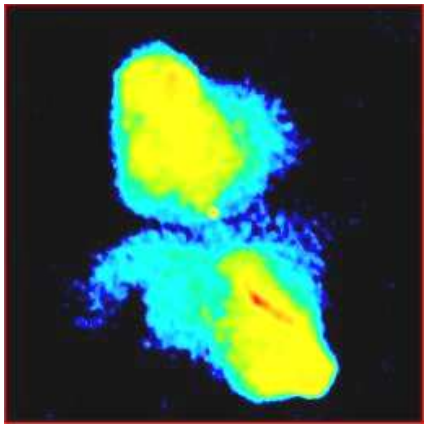
Perseus A or Galaxy 3C 84



http://images.nrao.edu/119

Galaxy Perseus A or 3C 84 is 235 million light years away. This is a curious object, which has features of Seyfert galaxy, radio galaxy and blazer. It was identified as a spiral galaxy and assigned as Seyfer galaxy class, but later on it appeared to be two colliding objects – spiral and elliptical galaxies. The collision that causes the activity is quite unusual. Huge core is similar to Seyfert galaxy's but the faint emission lines are more like blazers.

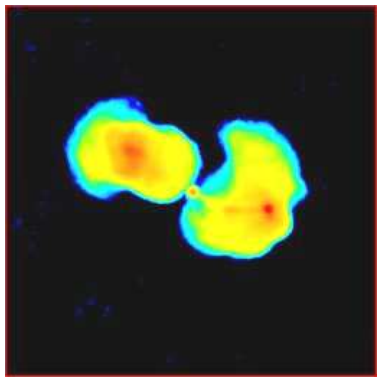
The radio galaxy 3C 401



http://www.jb.man.ac.uk/atlas/object/3C401.html

This galaxy is the furthest from my list. It is a powerful radio galaxy in the constellation of Draco the Dragon and is situated in a very centre of large cluster. It takes 720 mega parsecs to get to 3C 401 from the Earth. The galaxy has two bright outflows.

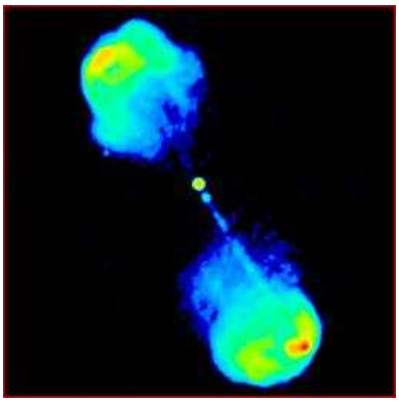
The radio galaxy 3C 388



http://www.jb.man.ac.uk/atlas/object/3C388.html

This galaxy is relatively close to the Milky Way, since the Sun is 8000 only parsecs away. It is a powerful radio galaxy with two similar outflows of the same brightness. However, one of the outflows is much bigger and a little brighter than the other. The brighter lobe possesses clearer jet and hotspot, but is located quite far from the galactic core. Maybe, there is more interstellar medium on the way of this outflow. It is also possible that the outflow has once collided with another non-active one.

The radio galaxy 3C 47

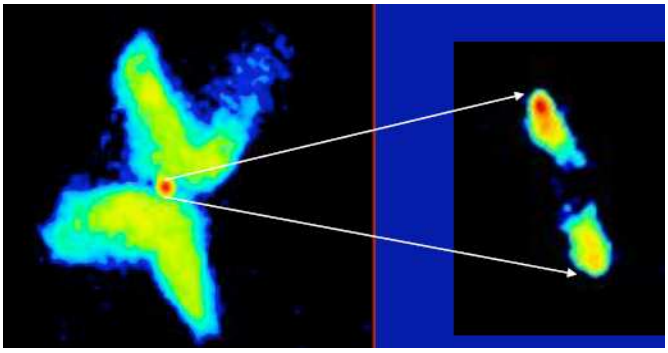


http://www.jb.man.ac.uk/atlas/object/3C47.html

This is an outstanding Seyfert galaxy with a quasar inside. I decided to mention it because 3C 47 is an excellent exemplar with big outflows and lobes that are clearly seen in radio waves. It is located relatively far from us and is a little blurred by Milky Way‘s background radiation. The distance between 3C 47 and the Sun is 4,3 billion light years. It could be a quasar with a double core, since I haven‘t found any information about 3C 47 colliding with other galaxy. I suppose that this second core is nothing but a lobe, which met a barrier and somehow returned to the core. I also assume that it could be two colliding – a core of Seyfert galaxy and

a quasar, but as soon as I know that the quasar is inside the galaxy, this bright hotspot area is just a reaction with interstellar medium. There is an example of such situation – binary star system of Gemini U. This is a red giant and white dwarf couple. The white dwarf, which gravitation field is bigger, absorbs the plasma from its sister. The plasma collides with interstellar medium and produces a lot of energy and radiation. I think that we have something like that happening with 3C 47, just there is no object to attract plasma.

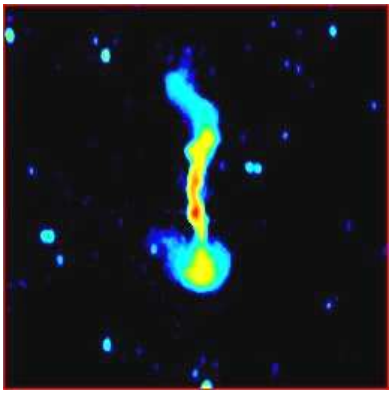
The radio galaxy 3C 315



http://www.atnf.csiro.au/research/Astro2008/Postings/Lakshmi_Saripalli.pdf

This butterfly like galaxy is 600 megaparsec away. Its outflows are very unusual – they remind X or a cross. There are some versions and theories of what caused such a curious form of the outflows. The first version says that the lobe meets a lot of interstellar medium which makes it move forward to galaxy's core, then meets another lobe and form that X shape outflow. The second version explains it as a collision of 3C 315 lobe with some dead galaxies lobes. I agree with the second explanation.

The radio galaxy 3C 449



http://www.jb.man.ac.uk/atlas/object/3C449.html

This is a relatively weak radio galaxy. It is 485 parsecs away from the Sun. The area around the galactic core and lobes are far brighter and the outflows. This fact causes galaxy's weak radiation. The galaxy is located in a small galactic cluster. Some of these neighbour galaxies are active, but their activity is quite low. Having done some researches, I got a picture of that galaxy surrounded by a bright halo, which gives a start of wide and very noticeable lobes. Upper lobe's density increases with the distance from core, and at the end of the second lobe

is even brighter than the galaxy‘s core itself and becomes a hotspot. That hotspot has a shape similar to the 3C 388 radio galaxys. Galactic core is closer to the paler lobe. Possibly, it's just an illusion that occurs when the galaxy is seen under a certain angle.

Discussion of results

Gamma rays are seen in Virgo A, Centaurus A, Perseus A, 3C 47, 3C 315, 3C 388, 3C 288, 3C 401, 3C 449, 3C 236 galaxies.

X-rays of most of the galaxies are obscured by the background radiation of the Milky Way. It is especially evident with Virgo A radio galaxy.

Microwave images can only show us the nearest galaxies – Centaurus A and Virgo A.

Only Centaurus A, Cygnus A and Virgo A radio galaxy were visible in radio waves, while part of oher galaxies were obscured by background radiation of the Milky Way.

The nearest radio galaxies Centaurus A and Cygnus A, appear best at the long spectral waves section, while the further radio galaxies 3C 315, 3C 47, 3C 449, Perseus A, 3C 388, 3C 288, 3C 401 and 3C 236 are visible in short (gamma) radiation.

When compared with other galaxies radio galaxy Virgo A, which is located only 60 million light-years away from us, is better seen at X-rays than other more distant galaxies.

In conclusion, I must say, the more distant the galaxy is, the better it is visible in gamma rays. It can be explained by the high penetration of gamma rays.

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