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ON THE NATURE OF THE EMISSION FROM THE GALAXY NGC4486

I. S. SHKLOVSKY

Sternberg Astronomical Institute, Moscow, U.S.S.R.

It is well known that the radio galaxy NGC4486 has as a striking peculiarity a small and very bright 'jet' in its central part. It seems to us that the key to the understanding of the nature of this radio galaxy is the purely continuous spectrum of the jet, where not even a slight trace of emission or absorption lines is present.

Also in the case of the Crab nebula we meet intense continuous optical emission accompanied by powerful radio emission. Some time ago we gave a new interpretation of the continuous optical emission from the Crab nebula. This emission is caused by the same mechanism of a non-thermal character that causes radio emission, namely by relativistic electrons in magnetic fields [1].

There are reasons to suggest that the nature of the continuous optical emission of the 'jet' of NGC4486 is similar. From our calculations (Shklovsky, 1955) [2] it follows that the intensity of the magnetic field in the region of the 'jet' is of the order of 10^{-4} gauss, i.e. approximately the same as in the 'amorphous' part of the Crab nebula. As a consequence the energy of the relativistic electrons responsible for the optical emission of the 'jet' must be of the order of 10^{11}–10^{12} eV., and their concentration about $5 \cdot 10^{-9}$ cm.$^{-3}$. The electrons with energies of the order of 10^{9}–10^{10} eV. should be much more numerous in this case. The region of the 'jet' thus has to be a powerful generator of relativistic particles. The unusual conditions prevailing there are apparently favourable for the acceleration of particles. An obvious assumption is that the acceleration is caused by a Fermi statistical mechanism.

Relativistic electrons formed in the central part of NGC4486 will diffuse into the surrounding space and in the course of 1 to 2 million years (the time during which the 'jet' is formed) they will fill a considerable part of the volume of NGC4486. Wandering through the weak interstellar magnetic fields of that galaxy, the relativistic electrons will radiate in the range of

radio waves, which is the cause of the anomalously high radio emission of NGC4486

The quantitative theory developed by us shows that the mean concentration of relativistic electrons with energies E greater than 5.10^8 eV. in NGC4486 is of the order of 5.10^{-8} cm.$^{-3}$, and their differential energy spectrum $dN(E) = KE^{-3}dE$. The total energy of the relativistic electrons is about 5.10^{56} ergs over the whole radio galaxy NGC4486. The number of particularly energetic 'luminous' relativistic electrons with E about 10^{11}–10^{12} eV. located in the region of the 'jet' is millions of times less than the number of less energetic relativistic electrons, that fill a considerable part of the volume of NGC4486 and cause its radio emission.

Supposing that the optical emission of the 'jet' continues to exist for 10^6 years with the observed intensity, we find that during this time-interval the relativistic electrons lose about 2.10^{55} ergs of their energy by radiation. This gives a new estimate of the energy needed for the process that is the initial cause of the anomalous phenomena going on in NGC4486. This energy is one-and-a-half order lower than the total energy of relativistic electrons in NGC4486, estimated above. It may be considered as the lower limit of the energy needed for the formation of the 'jet'.

We may point out that the radio emission of NGC4486 in 10^6 years, integrated over the spectrum, will be about 10^{54} ergs, i.e. considerably less than the amount of energy lost by the electrons of the 'jet' in the course of the same interval of time. This may be explained by the fact that the relativistic electrons in the interstellar medium of NGC4486 are losing their energy extremely slowly. They will cause radio emission for at least 5.10^8 years. The 'jet' will become dispersed in the course of that time and its visible traces will disappear.

An extremely important conclusion follows from this suggestion: there may be observed radio galaxies with radio emission entirely similar to NGC4486, but without any peculiarities in their optical radiation.

It may be considered that all relativistic electrons that fill the volume of NGC4486 were formed in result of a *single* outburst. It is more natural, however, to suggest that the 'jets' in NGC4486 are a recurrent phenomenon, and that the relativistic electrons that have filled NGC4486 were formed as a result of 10–20 outbursts.

What is the nature of a 'jet' (or of 'jets')? Two hypotheses may be suggested.

(1) The 'jet' has originated as the result of a certain enormous explosion in the central part of NGC4486. In this case it should be assumed that the energy emitted during such an explosion is enormous: it is hundreds of

millions times greater than during an outburst of a supernova. Similar phenomena are unknown in modern physics or astrophysics. The development of such a hypothesis raises numerous difficulties.

(2) The anomalous conditions in the central part of NGC4486 are caused by collisions of massive aggregates (of the type of large globular clusters) containing interstellar gas. These aggregates, extremely numerous in the spheroidal galaxy NGC4486, must have velocities of about 500–800 km./sec. and 'frontal' collisions between them may, in a similar fashion as in the case of the colliding galaxy Cygnus A, be the cause of a generation of considerable numbers of relativistic particles.

In [2] it was predicted that a considerable polarization of the optical emisssion of the 'jet' is expected. Special observations of this phenomenon are very desirable.*

REFERENCES

[1] Shklovsky, I. S. *Proc. Acad. Sci. U.S.S.R.* **90**, 983, 1953.
[2] Shklovsky, I. S. *Astr. Zj.* **33**, N 3, 1955.
[3] Baade, W. *Ap. J.* **123**, 550, 1956.

* Editor's note (added in proof): This polarization has since been observed by W. Baade[3].