Search for γ Radiation from the Cygnus A Radiosource.

A. BRACCESI and M. CECCARELLI

Istituto di Fisica dell'Università - Bologna

G. SALANDIN

Istituto Nazionale di Fisica Nucleare - Sezione di Padova

(ricevuto il 11 Maggio 1960)

Summary. — An experiment is described attempting to detect energetic γ-radiation from a peculiar celestial object (Cygnus A) interpreted by some authors as a collision between a galaxy of matter ond one of anti-matter. The experiment was negative and settled as upper limit for the γ-flux a value of about $5 \cdot 10^{-3}$ quanta/cm^2 s, which is about two orders of magnitude smaller than estimated by Morrison under the assuption previously mentioned.

1. – Introduction.

In several occasions the hypothesis has been advanced that in nature might exist comparable amounts of matter and anti-matter, the two forms being independently aggregated in large bodies having very little mutual interaction so to allow the essential stability of the universe.

The physical properties of the two forms of matter being of course identical the only chance of testing this hypothesis would be either to obtain actual samples of extragalactic matter, as for instance extreme energy cosmic rays, or to have the chance of observing the almost certainly unconventional features of collisions eventually occurring somewhere in the sky between two large aggregates of matter and anti-matter.

The two major phenomena observable in such a collision, pointed out respectively by HOYLE and BURBIDGE [1] and by MORRISON [2] are:

---

(1) F. HOYLE and G. R. BURBIDGE: *Nuovo Cimento*, **4**, 558 (1956).

(2) P. MORRISON: *Nuovo Cimento*, **7**, 858 (1958).

a) Emission of fast electrons through the chain $\mathcal{N}+\bar{\mathcal{N}} \to \pi \to \mu \to e$ and hence, in presence of magnetic fields, strong synchrotron radio emission.

b) Emission of soft γ-rays from electron-positron annihilation and of γ-rays in the vicinity of 100 MeV from π^0 decay.

Were the emission of radio or soft γ quanta may be originated in a number of other phenomena, energetic collimated γ's would be almost unmistakable fingerprints of an annihilation process.

Because of the concomitance of processes *a*) and *b*) the celestial objects *a priori* better suited for a search of annihilation γ-radiation are the strong and highly brilliant extragalactic radio-sources; the leader of this class for the terrestrial sky being the Cygnus A source.

The very high radio brilliance of this object, the accurate correspondence between its radio co-ordinates and the optical ones of an object interpreted by BAADE and MINKOWSKY (3) as two closely colliding galaxies and, finally, statistical considerations on the distribution of radiosources of the same class of brilliance strongly point out that the Cygnus source is indeed a highly peculiar encounter of two galaxies.

2. – γ-flux estimates and experimental results.

Estimates of the γ-flux in case the Cygnus A source were the collision between a galaxy and an anti-galaxy have been done by MORRISON (2) and by SAVEDOFF (4).

The former, in the hypothesis of an head-on collision of two clouds of gases of essentially known mass and velocity (3) estimates a flux at the top of our atmosphere of about 1 γ quantum/cm^2 s. The latter assumes that about the same amount of energy feeds the radio and the γ channels or, in other words, that magnetic fields intensities and gas densities are such to allow practically full conversion ot the fast annihilation electrons energy into radio waves. From the experimental value of the energy flux of this channel one gets for the γ-flux the much discomforting value of $5 \cdot 10^{-7}$ quanta/cm^2 s; a value quite outside the present experimental possibilities.

In the experiment we are going to describe we have not detected δ radiation from the Cygnus source up to a limit of $5 \cdot 10^{-3}$ quanta/cm^2 s; well outside the Morrison estimate. For those who like to maintain the hypothesis that in the source matter and anti-matter are interacting, our experiment points

---

(3) W. BAADE and R. MINKOWSKY: *Astrophys. Journ.*, **119**, 206 (1954)
(4) M. P. SAVEDOFF: *Nuovo Cimento*, **13**, 12 (1959).

out the opportunity of postulating some sort of magnetohydrodynamical process able to prevent the two clouds of interstellar gas to undergo full contact.

3. – Details on the experiments.

A little stack of Ilford G-5 Nuclear Research Emulsions has been flown one hour at an altitude of 27 km (17 g/cm²) at the time of culmination of the Cygnus source. Since this source has a declination of +40.5°, not very different from the latitude of the site of the experiment (44.5)°, a collimated γ-beam will lead, in spite of rotations of the balloon, to electron pairs all forming angles of less than 7 degrees with the vertical of the stack.

In order to reduce background due to the soft component of cosmic radiation the emulsions were made to turn automatically by 180 degrees on a horizontal axis after a time corresponding to the ceiling of the balloon, this being predetermined to occur half hour before the culmination of the source, and again by the same amount after one hour at the time of release. In this way the plates had the proper orientation only during the high altitude part of the flight and hence were not contaminated by ground level or intermediate altitude electron pairs, except for albedo.

In addition to the mechanism for rotating the plates the gondola contained a mercury barometer and a termometer with continuous recording as well as a device which, by taking a sort of picture of the sun ensured that the equipment was not swinging significantly.

The equipment had a total weight of 2 kg and was flown by means of a neoprene Darex 1750 g balloon fitted with a release valve ([5]). The bal-

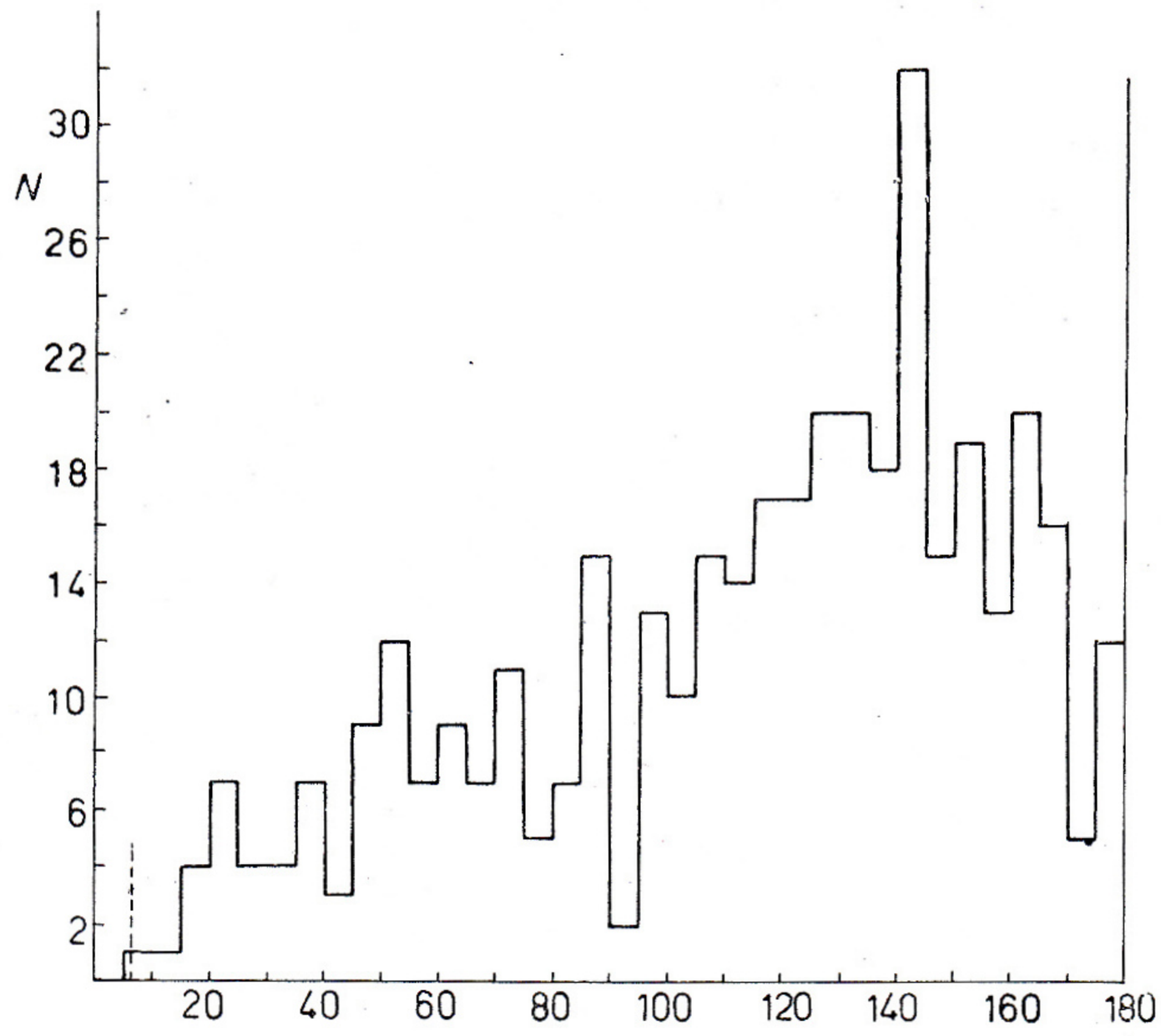

Fig. 1. – Number of electron pairs as a function of the zenithal angle. The dotted line limits the angular region in which γ's from the Cygnus A were expected.

([5]) J. E. Laby, Y. K. Lim and V. D. Hopper: *Nuovo Cimento*, **5**, 249 (1957).

loon performance for day flights was excellent; we were also able to secure exposures at night, although with less reliability because of the increased fragility of balloons.

In Fig. 1 is plotted the angular distribution of the electron pairs referred to the vertical of the stack. The dotted line at the left of the figure limits the region within which was expected the radiation from the Cygnus source. The fact that the majority of the γ particles do apparently enter from the bottom of the stack ($\theta > 90°$) shows the effectiveness of the procedure used for reducing the background.

The results of a double scanning have shown that, at least for flat electron pairs of an energy around 100 MeV, the loss is not likely to be larger than 50 %. By taking into account the scanning loss, the matter above the plates, the conversion mean free path, etc., it results that one electron pair corresponds to a flux of $5 \cdot 10^{-3}$ γ quanta/cm^{2}s. About this value is then the sensitivity of our expriment and hence the upper limit we can give for γ-radiation from the Cygnus A radiosource.

* * *

Professor PUPPI is cordially acknowledged for his suggestions and encouragement, Professors MANNINO and QUARENI and Mrs. STAGNI and TONNI for help during the flights, Mr. COLLINA for the skilful construction of the equipments.

RIASSUNTO

Si descrive un esperimento con il quale è stato tentato di mettere in evidenza radiazione γ energica proveniente da un particolare oggetto celeste (Cigno A) supposto da alcuni autori essere una collisione tra una galassia di materia ed una di antimateria. L'esperimento ha dato risultato negativo, ed ha permesso di stabilire per il flusso γ un limite superiore di circa $5 \cdot 10^{-3}$ quanti/cm^2 s, valore di circa due ordini di grandezza inferiore a quello stimato da Morrison nell'ipotesi precedentemente menzionata.