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COHERENT AND INCOHERENT RADIO EMISSION FROM EAS

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xperiment performed at the "Northern Cross" Italian Radio Telescope, ses from Extensive Air Showers (EAS) have been simultaneously at 30 MHz. and 408 MHz. One of the aims of this experiment was to e the presence of radio emission from the shower disc in the U.H.F. well as to confirm the emission at lower frequencies.

positive results have been obtained, and reported elsewhere, (1) it is to try to elucidate the coherent or incoherent nature of the emission. ve wish to attempt an explanation of our data, to make further comments ld a few results obtained; a more detailed analysis having been done for quency channels on 500 traces, corresponding to triggering EAS of most energy $\sim 5x10^{15}$ eV.

:pected a radio pulse at 6.3 μs on the traces of a 10 μs time base of a .m oscilloscope.

races were read in pulse–height at 6.3 μs and 6.5 μs and the readings ed with similar measurements at 2 μs and 4 μs.

detectors, for both frequency channels, were diodes which behaved as aw detectors for input signals <300 mV. For larger signals, instead, they l as linear detectors. (2)

use of this change of law of the detector there is an uncertainty region onding to those pulses generated by input signals of $\sim$300 mV.

pulses have been omitted from the analysis.

ie assumes an integral primary cosmic ray spectrum of the form N (> E) (with $\gamma = 2.2$ in our energy range (3)) one would espect an integral height spectrum of the form $N (>V) = K (V)^{-\gamma}$ with $\alpha = \gamma$ for coherent on and linear detector and $\alpha = \gamma/2$ if the detector is a square law detector, s for incoherent emission the slope of the pulse–height spectrum would be γ rispectivley.

'ig. 1 are plotted the integral pulse–height spectra for both our frequency els.

a) of the figure shows the 30 MHz. spectrum; in the square law region of tector the slope is -1.9 ± 0.5 and -2.8 ± 0.7 in the linear region. Part b) the 408 MHz. data which have a slope of -2.7 ± 0.7 for "square law" iour and -5.3 ± 1 for "linear" behaviour. A big source of uncertainty, for the 30 MHz. data comes from the aerial beam (~40°) pointed to the zenith and the magnetic field wich has a dip angle of 60°43'. This makes the nearly vertical showers wich are a large percentage of all showers in an infavourable position according to geomagnetic pulse production theory. The pulse–height from EAS depends, also, from the angle between the shower axis direction and the direction of the aerials polarization.

Taking this considerations into account the observed slopes are in good agreement with coherent emission expectations at 30MHz. and with incoherent predictions at 408MHz.

At 30 MHz. the reference channels spectrum gives a slope of ~–10 and at 408MHz. ~–11.

In the linear region of the 408MHz. detector the pulses observed were very few, as pointed out before (1) which makes the conclusions quite difficult.

Furthermore the signal to noise ratio for this channel was only ~0.26 which means that most pulses were at noise level or buried into the noise.

This makes the whole pulse–height spectrum ambiguous.

According to Kahn and Lerche coherent emission theory (4), coherence should be progressively lost at wavelengths shorter than the shower disc thickness, no emission is expected at frequencies greater than ~ 100MHz.

We have plotted, in Fig. 2 the frequency spectrum obtained with our data as well as points, at different frequencies, from Jodrell Bank (5) and Haverah Park data (6). It must be pointed out that Jodrell Bank data belong to showers of about the same size than ours whereas Haverah Park data to showers one order of magnitude bigger.

It can be seen that the spectrum falls off with increasing frequency. The contribution to the lower part of the spectrum could be due to a component of incoherent radiation as has been suggested (5, 7, 8, 9, 10).

On the other hand H.R. Allan (11) has pointed out that different showers strike the array at various zenith angles and their cores fall at unknown distances from the aerial,

The coherence conditions may, therefore, be very different and the pulses observed belong to different part of the disc. Even if the available data in the U.H.F. region seem to agree with incoherent emission from an EAS, a coherent tail at high frequencies cannot be excluded.

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REFERENCES

(1) M. GALLI, G.G.C. PALUMBO, G. SINIGAGLIA: Proc. Int. Conf. Cosmic Rays, EAS–65, Budapest (1969).

(2) N. MANDOLESI, G.G.C. PALUMBO, G. SINIGAGLIA, G. TOMASSETTI: Internal report, to be published.

(3) K. GREISEN: Proc. Int. Conf. Cosmic Rays, vol. 2 (London 1965), p. 609

(4) F. D. KAHN, I. LERCHE: Proc. Roy - Soc., A 289, 206 (1966).

(5) R. E. SPENCER: Nature, 222, 460 (1969)

(6) H. R. ALLAN, R. W. CLAY, J. K. JONES: Proc. Int. Conf. Cosmic Rays, EAS – 66/1, Budapest (1969).

(7) J. L. ROSENTHAL, M. L. FILCHENKOV: Izv. Akad. Nauk, 30, 705 (1966).

(8) D. J. FEGAN, P. J. SLEVIN: Nature, 217, 440 (1968).

(9) W. N. CHARMAN, J. V. JELLEY: Nuovo Cimento B, 63, 473 (1969).

(10) D. J. FEGAN, D. M. JENNINGS: Nature, 223, 722 (1969).

(11) H. R. ALLAN: Rapporteur paper, Int. Conf. Cosmic Rays, Budapest (1969) and private comunication.

FIGURE CAPTION

FIG. 1 INTEGRAL DISTRIBUTION OF PULSE–HEIGHTS

Part a) 30 MHz AERIAL
Part b) 408 MHz AERIAL
DOTTED LINE = REFERENCE CHANNELS 2 µs and 4 us

SOLID LINE = SIGNAL CHANNELS 6~3 µs and 6.5 us

FIG. 2 RADIO PULSE FREQUENCY SPACTRUM

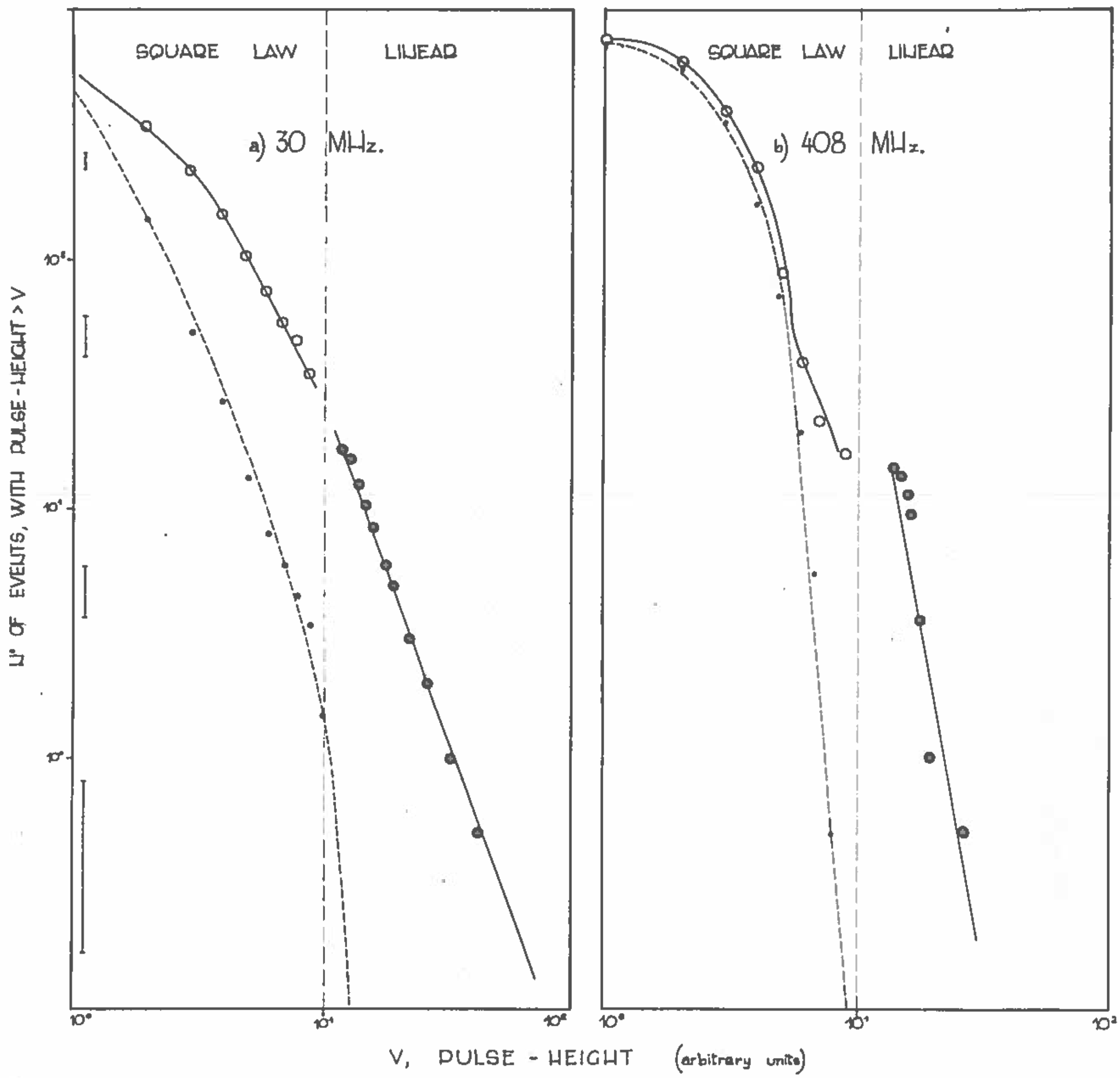
SQUARE LAW
LINEAR
a) 30 MHz.
SQUARE LAW
LINEAR
b) 408 MHz.
N° OF EVENTS, WITH PULSE - HEIGHT > V
V, PULSE - HEIGHT (arbitrary units)

FIG. 1

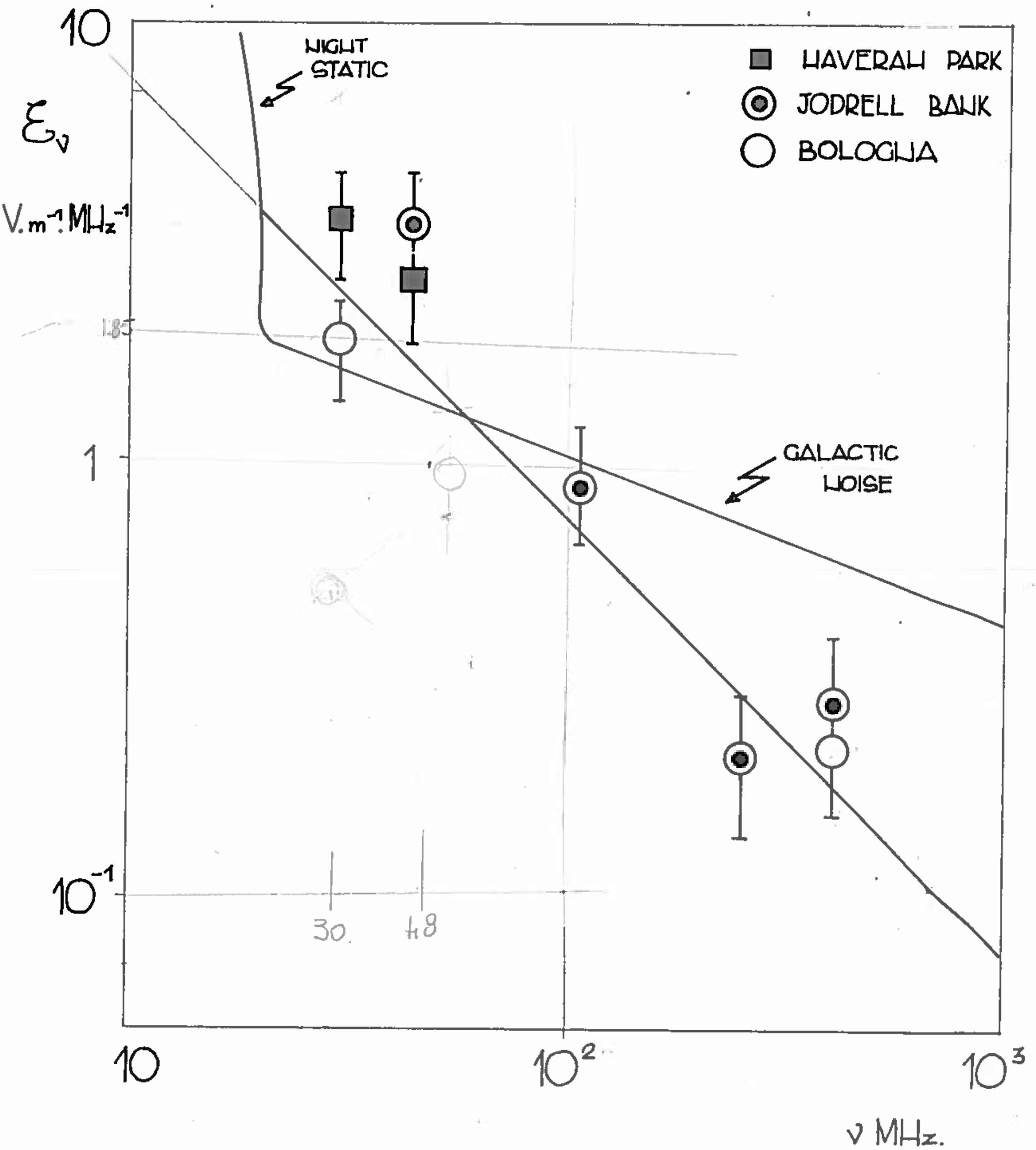
10
$\mathcal{E}_\nu$
$V.m^{-1}.MHz^{-1}$
1
10^{-1}
NIGHT STATIC
HAVERAH PARK
JODRELL BANK
BOLOGNA
GALACTIC NOISE
30.
48
10
10^2
10^3
ν MHz.

FIG. 2