I think that the article should be published. I deplore the old-fashioned outlook still prevalent after half a century of relativity, but there are so many sinners in this respect that I would not like Mr Isaak to be made a scapegoat for them all. I can only hope that he will read these remarks and consider whether it is not time to think in a more modern way.

J. L. SYNCE

Pulsars and the Mass Spectrum of Cosmic Rays

Now that it seems probable that pulsars are fast spinning neutron stars and that they generate relativistic gas including perhaps all or most of the cosmic rays^{1,2}, there is a new interest in the mass spectrum of cosmic ray primaries.

In the present understanding of the pulsar process, any gas that is accelerated in the rotating magnetosphere must have originated either from infall of external medium along or near to the axis of spin, or from material lifted by electrical processes from the surface of the neutron star. External material should reflect the nuclear composition of the shell of the supernova explosion that gave rise to the neutron star. (Infall at a later epoch, when the supernova shell has dissipated and when ordinary interstellar gas would be available, cannot be a major source of cosmic rays because at that stage the rotational energy remaining in the star is down to a small fraction of the original value.)

Gas liberated at the neutron star surface is likely to represent, at least in part, material that has suffered compression to nuclear densities, and subsequent decompression in the turbulence of the original implosion. That component will thus have the nuclear composition into which matter breaks up in the decompression process, a unique composition different from the general abundance of nuclides. The cosmic ray beam may thus contain, if this conjecture is correct, some admixture of this composition, modified subsequently, no doubt, by spallation near the pulsar or in interstellar space.

This component is not at all likely to be similar in fine detail to the general elemental abundances. While the acceleration process may introduce substantial selection according to the mass of the particle and its charge-to-mass ratio, and therefore generate some gross distortions in the final mass spectrum generated, it is not capable of introducing large changes over a small range of masses or charge-mass ratios.

The cosmic ray beam may therefore contain detailed evidence of its origin in neutron stars, in the form of fine detail in the relative abundances of tens or hundreds of nuclear species, and the attempts to measure its mass and charge spectrum have therefore a new significance: through this it may be possible to verify the pulsar hypothesis. Other suggested modes of origin, even an origin in the supernova explosion itself, would not be expected to result in the inclusion of decompressed neutron star matter.

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¹ Gold, T., *Nature*, **218**, 731 (1968).

² Gold, T., *Nature*, **221**, 5175 (1969).

High Energy X-ray Study of M-87

ON October 25, 1968, we searched for X-rays from M-87 using a balloon-borne detector. The detector consisted of two xenon proportional counter arrays with a combined sensitive area of 2,000 cm². The electronic systems of the two arrays were identical, and they operated completely independently. A five channel pulse height analyser in each system covered the energy range from 15 keV to 65 keV. Pulse shape discrimination circuits were used successfully to suppress the background radiation¹. The collimation for both systems was 13° FWHM. The azimuth of the detector was stabilized by a servo-compensated torque motor, using the Earth's magnetic field as a reference. An on-board control device changed the azimuth and zenith angles according to a programme set before launch. Crossed magnetometers and a Sun sensor measured the azimuth, and a shaft encoder measured the zenith angle. The energy channel settings and stability of the instrument were checked twice each hour during the flight by exposing the detector to a ²⁴¹Am radioactive source. The counting rate, housekeeping and orientation data were all photographically recorded on board.

The detector was launched from Palestine, Texas, and floated at a nominal atmospheric depth of 3.4 g cm⁻² from 1400 h UT until the payload was cut down near Valdosta, Georgia, at 2100 h UT. M-87 and the adjacent sky background were observed during the first three hours of float. Cygnus X-1 was observed for a scant five minutes before shutdown.

Our Cygnus X-1 data are fitted by the power law energy flux spectrum

$$(0.35 \pm 0.04) (E/30)^{-(1.0 \pm 0.3)} \text{ keV keV}^{-1} \text{ cm}^{-2} \text{ s}^{-1}$$

Cygnus X-1 is known to be variable and this result is near the maximum flux previously reported for this source².

We obtained an "effective" exposure to M-87 of 2,550 s, where by "effective" exposure we mean the integral over time of the fraction of the detector area exposed to M-87. We divided the three hour observation into five 900-second source observations alternated with six background observations. The azimuthal positions for the background observations were alternated between 36° east of M-87 and 36° west of M-87 (minimum zenith angle was 22°). From the data of the entire flight, we determined that the background counting rate varied with azimuth by nearly 1 per cent. The frequent alternation of the azimuth positions for the background measurements therefore proved crucial to the achievement of accurate results in this experiment. The background counting rate used in computing the source strength was taken to be the average of the background measurements made to the east and to the west of the source. The uncertainty in this background determination is included in our estimate of the systematic error in the results. Our methods of data analysis are described elsewhere³.

Table 1. UPPER LIMITS ON THE ENERGY FLUX FROM M-87

Channel (keV)	1 σ Statistical confidence (10 ⁻² keV keV ⁻¹ cm ⁻² s ⁻¹)	2 σ Statistical confidence (10 ⁻² keV keV ⁻¹ cm ⁻² s ⁻¹)
14.5-25.5	4.00	5.90
25.5-35	1.25	1.83
35-52	0.44	0.63
52-66.5	0.76	1.13

Table 1 shows the upper limits on the intensity of M-87 in each of several energy ranges. The values are corrected for atmospheric absorption and escape radiation⁴. We assumed a primary energy flux spectrum of the form $E^{-\alpha}$, with spectral index $\alpha=1$. The results are insensitive to the choice of α . The upper limits include an estimate of the uncertainty in our background determination. A 1 σ (2 σ) value is the intensity of M-87 at the top of the atmosphere such that the observed counting rate would be