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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part II

# II-3B-17. Emission of Carbon Group Heavy Nuclei from 3+ Solar Flare

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Discoverer satellite XVII was launched into a polar orbit at 2042 UT on 12 November 1960, about 37 min. after ground level neutron monitors indicated their maximum cosmic ray increase following a 3+ solar flare which commenced at 1325 UT. During the 50 hours between launching and successful recovery, it is estimated that the outside of the capsule received a bombardment of $\sim 2\times 10^9$ protons per $cm^2$ of energy $E > 30$ Mev[1]. The instrument capsule which carried a 772 gram block of Ilford G5 emulsion had an apogee of $993\pm 4$ km and a perigee of $188\pm 3$ km. The average latitude of apogee was 20° S and the perigee occurred at 18° N. Of the 31 orbits of 96.44 min. duration, a total of 0.766 days was spent above geomagnetic latitude 55°N and S.

The $10\times 15$ cm face of the emulsion block was placed adjacent to one wall of the aluminum capsule and radiation arriving perpendicular to this plane penetrated 2.2 g. $cm^{-2}$ of condensed matter composed of light nuclei. This admitted carbon nuclei with energies in excess of 88 Mev per nucleon over a solid angle of 1.8 steradians. Owing to other instrumentation in the capsule the rear of the block was shielded by approximately 21 g. $cm^{-2}$ of condensed matter.

As a result of desensitization of the emulsion by the intense proton bombardment coupled with very weak development[2], it is possible to discern the tracks produced by slow multiply charged particles with charges greater than 2. At very high magnification star-like structures of 3 to 6 tracks originating from a common center can be discerned against a single grain background of $2.5\times 10^{10}$ per cc. The grain density and range of these associated track clusters suggests that they are the spallation products of $Z\geq 3$ commonly produced when Br, Ag, or I emulsion target nuclei are evaporated.

Systematic examination of the first three 600 micron emulsion sheets facing the thin window at 600× magnification shows a group of tracks which enter the stack and terminate their range by ionization. For particles making small dip angles with the emulsion plane the grain density can be measured after suitable correction for coincident background grains. The histogram of the grain density in the terminal 300 microns of range (Fig. 1) shows a pronounced peak at 275±25 grains. If we plot the integral grain count

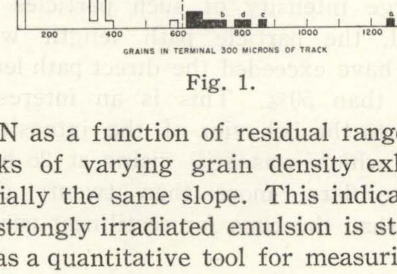


Fig. 1.

log N as a function of residual range log R tracks of varying grain density exhibit essentially the same slope. This indicates that the strongly irradiated emulsion is still serving as a quantitative tool for measuring ionization. It can be shown that a line of constant grain density intersects these functions at ranges R roughly inversely proportional to the charge Z. If we assign $Z=4$ to the tracks with an average count of $183\pm 17$ grains then the peak at $275\pm 25$ grains yields a charge of 5.9. The charge assignments for heavier nuclei, following this model, are indicated in Fig. 1. The peak with grain densities between 200 and 300 grains per 300 microns at the terminus is attributed largely to carbon nuclei emitted from the sun during the flare. They are about 100-fold more abundant than those observed in a similar emulsion block flown in polar orbit during 7 to 10 December 1960 under normal solar activity. The energy spectrum of the solar flare heavy nuclei is being investigated by measuring the ranges of the particles and the results will be presented.

**References**

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2) H. Yagoda, "Radiation Studies of Nuclear Emulsions and Metallic Components Recovered from Polar Satellite Orbits." Proc. of 2nd Inter. Space Science Symp., Florence, Italy, April 10-14, 1961, in press.

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part II

# II-3B-18. Heavy Nuclei in Solar Cosmic Rays

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Rocket borne nuclear emulsions flown into solar cosmic ray events during 1960 from Fort Churchill were examined for the presence of particles with charges greater than two. Heavy nuclei ($Z \geq 3$) in excess of normal galactic cosmic ray background were detected in small numbers in the solar particle beam which began to arrive at the earth on 3 September 1960. Subsequently, they were found in much greater abundance in the larger events of 12 November 1960 and 15 November 1960. The properties of these heavy nuclei including their charge, their energy, and their flux are presented, and their significance is discussed.

## §1. Introduction

Many properties of solar cosmic ray events have been studied using ground-level monitors, balloon-borne equipment, and satellites. In order to obtain more detailed information on the characteristics of the low energy portion of these phenomena, Nike-Cajun sounding rockets were used to carry nuclear emulsions and other equipment above the earth's atmosphere into several solar cosmic ray events. The rockets were launched from Fort Churchill, Manitoba, Canada, geomagnetic latitude 60.7°N, at which point the magnetic field of the earth does not prevent the entry of the low energy particles to be studied. This paper is particularly concerned with the detection of heavy nuclei in the three solar cosmic ray events studied and an examination of their properties.

## §2. Experimental Procedure

In order to determine whether or not heavy particles were present in the solar particle beam under consideration, a complete scan of the periphery of the four-inch diameter nuclear emulsion disks was made for delta-ray tracks, which had residual observable ranges in the emulsion of seven-hundred microns or more and were within a specified solid angle. After the elimination of the tracks which could be identified as slow alpha particles, the remaining tracks fell into two groups; those which had a residual range of the order of several millimeters or less, and those which had ranges in the emulsion of many centimeters or more. In each case the number in the latter group was found, within statistics, to be consistent with the expected cosmic-ray back-ground of 15 to 20 particles/