ISSN 0015—3206
FZKAAA 23 (4) 415 (1991)

ELEMENTAL COMPOSITION OF COSMIC RAY HEAVY NUCLEI OVER ALICE SPRINGS

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Received 22 October 1991

UDC 539.14

Original scientific paper

The sub-iron to iron flux ratio over Alice Springs has been estimated using balloon borne CR-39 (HCB) stack launched from Alice Springs for 32 hours at an atmospheric depth of 9.8 g $\cdot$ cm^{-2}. The estimated (Sc-Mn)/Fe flux ratio is in accord with the expected results after the model of Margolis and Bussard. The present result has also been compared with the derived estimate expected from the steady state homogeneous model in interstellar abundance after Protheroe et al. The active detector satellite borne data of Engelmann et al. lie considerably below the present result.

1. Introduction

Usually the supernova remnants are the principal source of cosmic rays in which Fe is the most abundant element. At the time of cosmic ray propagation the Fe primaries interact with the Interstellar Medium and also with the atmosphere and produce very heavy secondaries of the sub-iron components of the cosmic rays e. g. Mn to Ca. The sub-iron to iron flux ratio gives information about the path length distribution of the galactic comic rays which explains the propagation mechanism of the Galactic Cosmic Rays.

The secondary to primary flux ratio in the low Z region, e. g. B/C ratio, decreases with increasing energy and has been explained in terms of leaky box model with energy dependent leakage path length. But so far the explanation of the energy dependence of sub Fe/Fe flux ratio is concerned, the path length distribution requires truncation in the short path length region[1]. Protheroe et al.[2] gave a theoretical estimate for the energy dependence of the sub-iron to ion flux ratio which is based on exponential path length distribution adopted in slab model.

The theoretical estimate[2] of (Ca-Mn)/Fe flux ratio is supported by the observed results of different authors[3-8]. Above 2 GeV/n only satellite borne active detector data of Engelmann et al.[9] is available which lie appreciably below with the theoretical results[2].

In the present experiment the balloon borne CR-39 (HCB) and nuclear emulsion stack are launched from Alice Springs in 1983, flown for 32 hours at an atmospheric depth 9.8 g $\cdot$ cm^{-2} and has been used to estimate (Sc-Mn)/Fe flux ratio. The observed data has been corrected for fragmentation using the semiempirical fragmentation model of Silberberg and Tsao[10] and compared with the derived results expected from Refs. 1 and 2. The active detector data of Engelmann et al.[9] has also been considered in the present survey. The average energy of the Fe primaries obtained from nuclear emulsion data analysis was 3.5 GeV/n.

2. *The experiment*

A stack composed of 1600 μm thick CR-39 (HCB 0.5%) plastic sheets, nuclear emulsions of 50 μm ET-7B Fuji and X-ray films were flown from Alice Spr ngs where the vertical cut off rigidity is 10.3 GV which corresponds to an effective cut off rigidity of 4.1 GeV/n for ^{56}Fe primary nuclei. The exposure was made for 32 hours at 9.5 mbar residual atmosphere. The detail of this experiment is reported in Ref. 11. The charge spectrum has been determined from the analysis of track diameters in CR-39 (HCB) plastics. The energies of the very heavy components have been estimated from the distribution of the opening angles of alpha fragments, initiated by VH groups in nuclear emulsions. The observed VH fluxes have been corrected for fragmentation and nuclear interactions and is displayed in the Table 1.

TABLE 1.

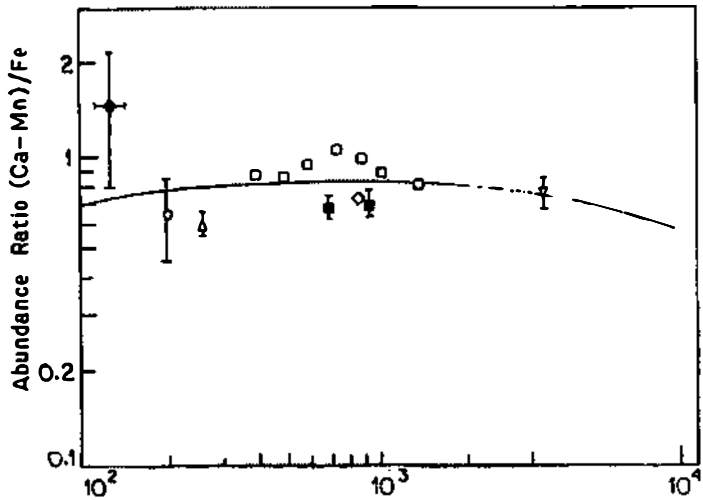
Elemental flux ratio	Present work
(Ca-Mn)/Fe	0.75$\pm$0.07
(Sc-Cr)/Fe	0.43$\pm$0.04

Elemental flux ratio obtained from balloon borne passive detector data[11] at 3.5 GeV/n energy.

3. *Results and discussion*

The observed (Ca-Mn)/Fe flux ratio can define the path length distribution at low energies. The calculated result is based on exponential path length distribution adopted in slab model by Protheroe et al.[2] and has been presented in Fig. 1 along with other observed results[3-8].

The present result on (Ca-Mn)/Fe flux ratio at energy 3.5 GeV/n agrees with the derived results from the slab model after Protheroe et al.[2].



Kinetic energy, MeV/*n*.

Fig. 1. (Ca-Mn)/Fe flux ratio plotted as a function of energy:

Experimental data:
- ○ Carturight et al.[3],
- △ Garcia-Munoz et al.[4],
- □ Maehl et al.[5],
- ■ Lezniak and Webber[6],
- ◇ Israel et al.[7],
- ◆ Ramadurai et al.[8]
- ▽ Present work.

Theoretical result:

———— Estimated after Protheroe et al.[2]

Another set of data on (Sc-Mn)/Fe flux ratio at different energies obtained from satellite borne Cherenkov detector measurement by HEAO-C3 group[9] has been displayed in Fig. 2 along with the balloon borne Alice Instrument data of Henkel et al.[12] and ours. The calculated results expected from the models[1,2] have also been presented in the same figure. It has been found from the figure that the (Sc-Mn)/Fe flux ratio data of Engelmann et al.[9] and Henkel et al.[12] lie appreciably below the theoretical results[1,2]. The present result at 3.5 GeV/n energy is in accord with the derived results[1,2]. The general cause of disagreement with the available data may appear due to the non availability of proper partial fragmentation cross section data and standard cosmic ray heavy ion propagation model, since the major portion of sub-iron flux viz. (Sc-Cr) are almost absent in the source region and are generated by the fragmentation processes of the dominant Fe nuclei at the time of propagation through the interstellar medium.

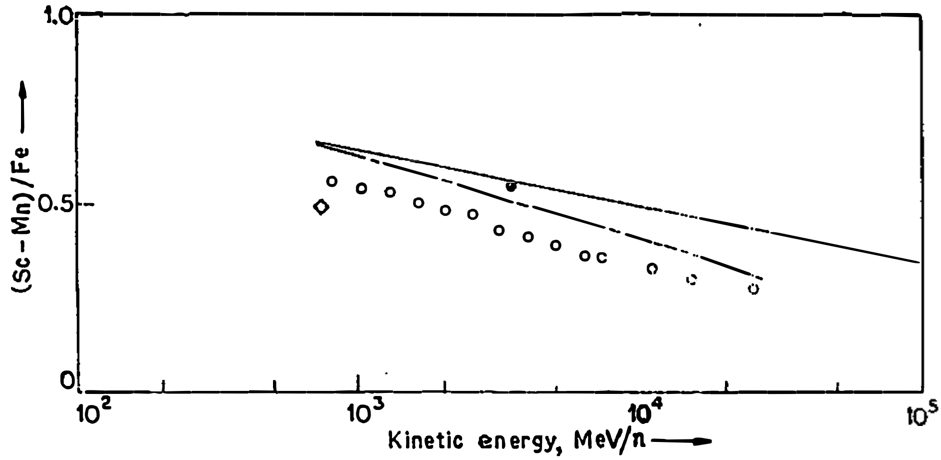


Fig. 2. (Sc-Mn)/*Le* flux ratio as a function of energy:

Experimental data:
o HEAD-C3 active detector data[9],
◇ Balloon borne active detector data[12],
● Present work.
Theoretical results:
Lover curve derived after Margolis and Bussard[1],
Upper curve derived after Protheroe et al.[2]

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OSNOVNI SASTAV TEŠKIH JEZGRI U KOZMIČKIM ZRAKAMA IZNAD ALICE SPRINGSA

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UDK 539.14

Originalni znanstveni rad

Omjer tokova podgrupe željeza prema željezu mjeren je iznad Alice Springsa koristeći CR-39 (HCB) detektor podignut balonom do atmosferske dubine od 9,8 g cm^{-2}. Procijenjen omjer (Sc-Mn)/Fe tokova je u suglasnosti s rezultatima modela Margolisa i Bussarda. Rezultat je također uspoređen s procjenom dobivenom iz tzv. stacionarnog homogenog modela Protheroa i suradnika.