INTERPRETATION OF COSMIC RAY COMPOSITION: THE PATHLENGTH DISTRIBUTION

R.J. Protheroe* and J.F. Ormes
Laboratory for High Energy Astrophysics
NASA/Goddard Space Flight Center, Greenbelt, MD, U.S.A., and
G.M. Comstock
Cosmo-Science Associates, Stony Brook, NY, USA

The chemical composition of cosmic ray nuclei with $3 \leq Z \leq 28$ between $\sim$100 MeV/nuc and a few hundred GeV/nuc are compared with a consistent set of propagation calculations. These include the effects of spallation (energy-dependent cross sections are used), escape and ionization loss in the interstellar medium and deceleration in the solar cavity. This has enabled a consistent study of the cosmic ray pathlength distribution to be made over this entire energy range. Details of the propagation calculation are left to a forthcoming paper.

It has been generally believed that the composition was best explained by a pathlength distribution (PLD) with an absence of short pathlengths (e.g. Shapiro et al., 1973). In an attempt to explain this truncated shape of the PLD, several models have been advanced. Simon (1977) has considered the "two-zone" models or "nested leaky box" models of Cowsik and Wilson (1973, 1975) and shown that in these cases the PLD is the convolution of two exponential distributions. The distribution is uniquely defined by two parameters: the mean pathlength in the source region λ_s, and the mean pathlength in the galaxy λ_b (the mean escape length is $\lambda_e = \lambda_s + \lambda_b$, and the ratio λ_s/λ_b determines the shape of the distribution).

We have used observed and predicted (Be+B)/C and B/C ratios to obtain λ_e. Below 2 GeV/nuc we find $\lambda_e \cong 7$ g/cm^2 for an exponential PLD ($\lambda_s/\lambda_b = 0$) and 5.3 g/cm^2 for $\lambda_s/\lambda_b = 0.5$ (the most extreme two-zone model). Above 2 GeV/nuc λ_e decreases as $E^{-0.4\pm0.1}$ (Ormes and Freier, 1978). These values are for an ISM comprising 90%H and 10% He by number

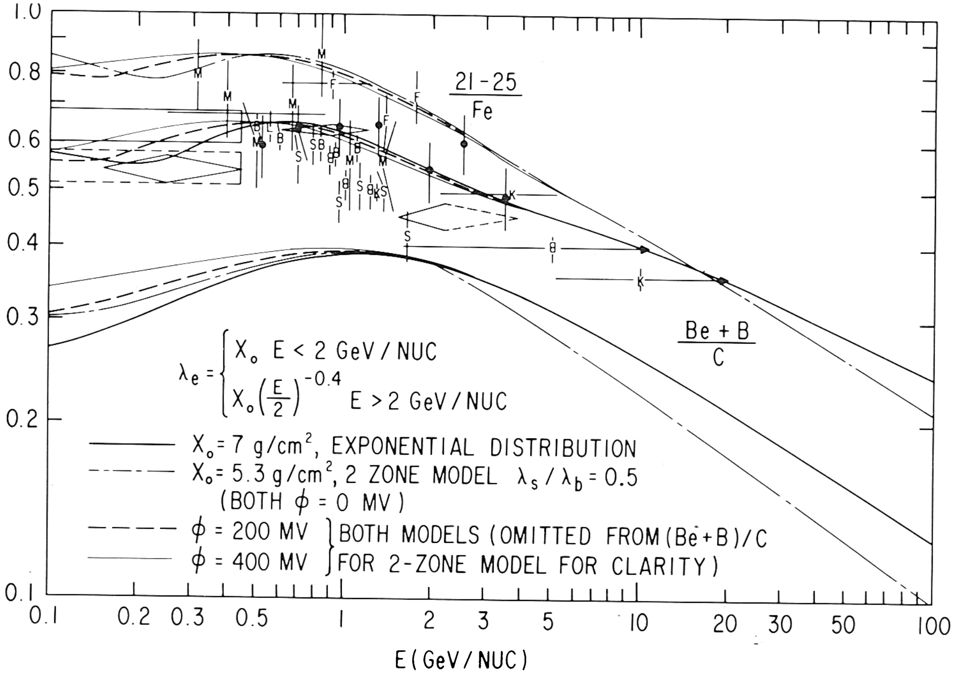
We have calculated the ratio of Iron secondaries ($21 \leq Z \leq 25$) to Fe and (Be+B)/C as a function of energy for these two cases. The predictions are shown in the figure where we also show the effect of varying the amount of solar modulation. The predictions for the ($21 \leq Z \leq 25$)/Fe ratio may be compared with a survey of the experimental results shown in the figure. From this comparison, it appears that there is no need to

* NAS/NRC Research Associate

G. Setti, G. Spada, and A. W. Wolfendale (eds.), Origin of Cosmic Rays, 107–108.
Copyright © 1981 by the IAU.

https://doi.org/10.1017/S0074180900074477 Published online by Cambridge University Press

invoke a truncated PLD to explain the observed ratio. The data are consistent with the predictions for the exponential PLD; however, because of the large amount of scatter between data points, we cannot rule out the possibility of small values of λ_s/λ_b.



VARIATION OF (Be+B)/C AND (21-25)/Fe WITH ENERGY. M, Maehl et al., 1977; L, Lund et al., 1975; F, Freier et al., 1979; B. Benegas et al., 1975; S. Scarlett et al., 1978; K. Koch, 1980, preliminary HEAO-C data; ●, Lezniak and Webber, 1978; ◇ , Israel et al., 1979; [dashed box], Garcia-Munoz et al., 1977; [solid box], Garcia-Munoz et al., 1979.

References

Benegas, J.C., et al., 1975: Proc. Munich Conf. 1, 251.
Cowsik, R., and Wilson, L.W., 1973: Proc. Denver Conf. 1, 500.
Cowsik, R., and Wilson, L.W., 1975: Proc. Munich Conf. 2, 659.
Freier, P.S. et al., 1979: Proc. Kyoto Conf. 1, 316.
Garcia-Munoz, M., et al., 1977: Proc. Plovdiv Conf. 1, 224.
Garcia-Munoz, M., et al., 1979: Proc. Kyoto Conf. 1, 310.
Israel, M.H., et al., 1979: Proc. Kyoto Conf. 1, 232 and 13, 402.
Koch, L., 1980: Bull. A.P.S. 25, 563.
Lezniak, J.A., and Webber, W.R., 1978: Astrophys. Space Sci. 63, 35.
Lund, N., et al., 1975: Proc. Munich Conf. 1, 263.
Maehl, R.C., et al., 1977: Astrophys. Space Sci. 47, 163.
Ormes, J.F., and Freier, P.S., 1978: Astrophys. J. 222, 471.
Scarlett, W.R., et al., 1978: Astrophys. Space Sci. 59, 301.
Shapiro, M.M., et al., 1973: Proc. Denver Conf. 1, 578.
Simon, M., 1977: Astron. Astrophys. 61, 833.

https://doi.org/10.1017/S0074180900074477 Published online by Cambridge University Press