ANTI-PROTONS IN THE PRIMARY COSMIC RADIATION

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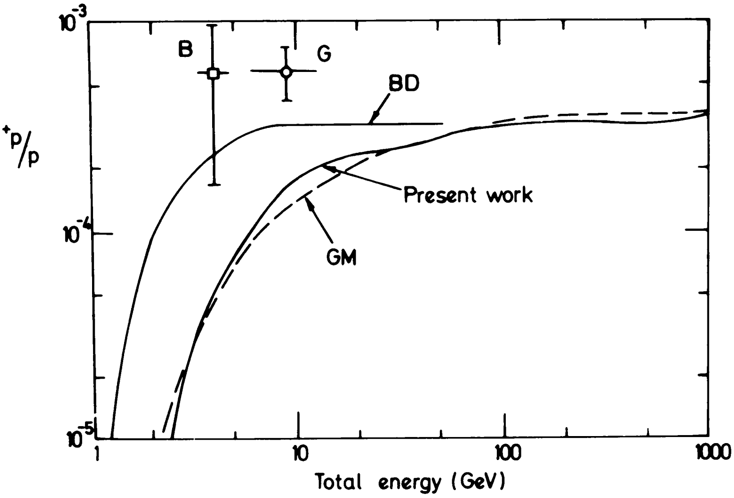
A knowledge of the flux of antiprotons is of value in examining the manner in which cosmic rays propagate, assuming, as is conventional, that the antiprotons arise from interactions in the I.S.M. Golden et al. (1979) have recently measured the $\bar{p}$/p ratio in the region of 10 GeV and, although confirmatory measurements are needed, it is instructive to compare with expectation. In a recent paper (Szabelski et al., 1980) we presented results of a new calculation of the expected $\bar{p}$/p ratio using the standard (equilibrium) 'leaky box model'.

The Figure shows a comparison of the measured ratio (including a measurement of Bogomolov et al., 1979) with our own, and other predictions (see caption for key); the predictions having been made



Comparison of observed and expected $\bar{p}$/p ratios.
B, Bogomolov et al. (1979); G, Golden et al. (1979); BD, Badhwar et al. (1975); GM, Gaisser and Maurer (1973).

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for a mean grammage traversed by cosmic rays of 5 gcm^{-2} (hydrogen) as expected from analysis of mass composition data. It is immediately apparent that not only is there a large discrepancy between the measured ratio and our own predictions but that the different predictions are disparate.

The source of the difference in predictions is not known, only a little is due to known input differences; using the same input cosmic ray spectrum the ratio of the GM value to ours for $\bar{p}$ of all energies is 0.74 and the ratio of the BD value to ours is 6.1. The closeness of GM to our value adds confidence.

A number of possibilities arise to account for the difference between the measured $\bar{p}/p$ ratio and our predictions. The measured ratio may be too high; however, we have analysed the sea level data with the same instrument for the μ^+/μ^- ratio and find good agreement with the Durham (and other) measurements of this quantity, thus giving confidence. Another possibility is that there is a contribution from 'genuine' extragalactic $\bar{p}$ from anti-galaxies; this cannot be discounted but seems unlikely for a number of reasons. The most likely explanation, in our view, is that the 'leaky-box' model of propagation is not accurate.

Our choice of propagation effects as the explanation stems in part from our earlier contention (Giler et al., 1977) that the grammage derived from an analysis of e^+ was not the same as that expected from mass composition studies. Specifically we found, using the leaky box model, $\lambda(e^+)$ increasing from $\simeq$ 2.5 gcm^{-2} at 2GeV to $\sim$ 8 gcm^{-2} at 50 GeV compared with λ (nuclei) falling from $\simeq$ 6 gcm^{-2} to $\simeq$ 3 gcm^{-2} between the same limits. Now we find $\lambda(\bar{p}) \simeq (18\pm5) gcm^{-2}$ at $\simeq$ 10 GeV. There are several ways of modifying the propagation characteristics to achieve these values; an attractive model is one where the lifetime distribution is not the usual exponential but has a much longer tail, energy losses for the positrons would reduce their flux (and thus reduce $\lambda(e^+)$) even at quite low energies. The difference between $\lambda(\bar{p})$ and λ(nuclei) could arise from protons (and α-particles) and heavier nuclei having sources differently distributed in the Galaxy.

References

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