

(Figure 9), which is consistent with the threshold seen in the HPCE spectrograms.

We plot the effect of an increasing temperature profile in the third column of Plate 2. A higher electron temperature improved the fit only slightly by the following mechanism; it reduced the losses at low M , low L , which in turn caused the fit to find a smaller diffusion coefficient in order to reduce the "blue" spot at $M \sim 0.1$ keV/nT. The gross deviations remain, however, implying that electron temperatures are not responsible for the poor fit.

Other Plasmasphere Models (Fits 8-10)

It may be that we have overestimated the density of the plasmasphere, particularly in view of the ISEE plasmasphere results. We therefore allowed the density of the GEOS plasmasphere to vary, and found a slightly denser plasmasphere, without any vast improvement in χ^2 (Fit 8). The ISEE plasmasphere, using a plasma-pause at $L=5$ appropriate for $Kp=2$ and choosing an average value of $16,000/L^{4.5}$ for the plasma trough, produced a distinctly degraded χ^2 (Fit 9). Finally, we reduced the neutral H geocorona by half (Fit 10), but without remarkable results. Thus χ^2 fits were unable to find a vastly better choice for any of the parameters of the standard model. Because the adjustable parameters in the diffusion model could not explain the data, we have inverted the problem to extract an empirical diffusion coefficient from the data.

Extracted Diffusion Coefficients

Several methods for extracting diffusion coefficients are detailed in SL. We describe two time-independent methods below, which are based on radial gradients in the data.

Integral method. Rewriting the diffusion equation as,

$$\frac{\partial}{\partial L} \left(\frac{D}{L^2} \left(\frac{\partial f}{\partial L} \right) \right) = \frac{1}{L^2} \left(\Lambda f - C \frac{\partial f}{\partial M} + \frac{\partial f}{\partial t} \right) \quad (9)$$

and integrating, choosing a lower limit at $L=1$, where $\partial f / \partial L = f' = 0$, (primes indicate $\partial / \partial L$) gives

$$D = L^2 (f')^{-1} \int_1^L \left(\frac{\Lambda f - C \partial f / \partial M + \partial f / \partial t}{l^2} \right) dl \quad (10)$$

Note that the integral is over the loss terms in the equation. We assume steady state, so that $\partial f / \partial t = 0$, and we assign theoretical values to the Coulomb and charge exchange rates. The data enter the equation as gradients of the phase space density in both L and M , which can become very large with noisy data. SL attempt to avoid this problem by casting their equation in terms of logarithms, $F = \ln(f)$, with gradients in F rather than f . This gives us the following related equation:

$$D = L^2 (f F')^{-1} \int_1^L \left(\frac{\Lambda - C \partial F / \partial M + \partial F / \partial t}{l^2} \right) f dl \quad (11)$$

Two more problems arise in practice. Since the loss terms are largest near the Earth where the phase space densities are least well known, we are integrating over the least accurate part of the data set first. Thus a small error at low L shell may propagate upward and contaminate the entire determination. We could use zero for the initial integration constant, or we can determine the integration constant for some $L > 1$ by using the result from the logarithmic method described below. We can then integrate from that point upward in L . Both methods give qualitatively similar results, indicating that the method is insensitive to the lower boundary condition.

then differentiate the left hand side of equation (9) to get,

$$D = \frac{\Lambda - C \partial F / \partial M + \partial F / \partial t}{(n-2) F' / L + (F')^2 + F''} \quad (12)$$

where the value of n can be determined iteratively, for some subinterval in L .

The drawback is that we now have a second derivative in amplifying data fluctuations. We have attempted to reduce the problem by incorporating smoothing into the data averaging algorithm. If the iterative subinterval is smaller than the data interval there may no longer be a single power of n to describe the diffusion coefficient; i.e., $D = c L^{n(L)}$. Although not a standard form for the diffusion coefficient, a peaked coefficient has been found before [West *et al.*, 1981] and can identify the regions in which the conventional theory fails.

Extracted coefficients. Plate 3 shows the diffusion coefficient for H^+ , He^+ , and He^{++} as derived using the two methods described above. In the third column, we show Cornwall's [Cornwall, 1977] theoretical diffusion coefficient as used in the reference and SSF solutions. The first column illustrates the difficulty with the logarithmic method. The speckled nature of the solution results from noise in the data becoming amplified by the first and second derivatives despite the use of two-dimensional β splines [Bartels *et al.*, 1983]. The second column shows the smoother character of the integral method. We have initialized the integral to zero at the bottom of the data since the normalization has little effect on the overall coefficient.

Both methods are within a factor of 10 of the SSF value at $L > 5$ but below $L \sim 5$ the extracted diffusion coefficient is several orders of magnitude greater than the theory. We cannot adjust the theory to agree with the extracted coefficient over the entire L range. This arises from the L^{6+} dependence of D_{LL} in the theory, which forces the coefficient to increase dramatically between $L=2.5$ and $L=5$. In contrast, Plate 3 shows no such dramatic change in the extracted coefficient over this range of L . We found no reference in the literature to explain or anticipate this result.

For $M > 1$ keV/nT protons, there is a sharp decrease in the deduced diffusion rate. This decrease appears not to be merely an artifact of the integration starting point, since it occurs for both methods, though at slightly different energies. The deduced diffusion coefficient is more in line with the theory at these higher energies. This may account for the discrepancy between this result and that reported for inner radiation belt protons [Croley *et al.*, 1976], since this enhanced diffusion only occurs at lower energies than the previously analyzed MeV H^+ .

A second observation evident in the second column for both H^+ and He^+ , is the "valley" in the coefficient, centered around 0.1 keV/nT and $L \sim 5$. A diffusion coefficient such as Fälthammer's general form, has a monotonic power law dependence in both L and M . Such a power law coefficient cannot fit the entire range of data. Since the method integrated over the theoretical loss rate, one possibility is that we improperly estimated the loss rate for this region, leading to a peaked diffusion coefficient. An examination of the charge exchange rates from Figure 8 revealed that the rate for H^+ electron capture from neutral H has a peak in this region. Since that cross section is probably the best known of the cross sections we use, it suggests that the neutral densities may be incorrect. We recalculated D_{LL} to examine the effect of reducing the exobase neutral H density by half, but the effect was slight, and did not help the helium fit. This is instructive, because none of the other