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Radiation Belt Helium Ions: Steady-State Model Distribution in Pitch Angle, L-shell, Energy and Charge State

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For geomagnetically confined helium ions at 10 keV to 50 MeV, we have considered a model that includes the combination of radial diffusive transport, the effects of Coulomb collisions, and the effects of the three charge exchange reactions (two "internal", and one "external" loss causing). In describing the distributions, we have included four independent parameters: geomagnetic L-shell, the first adiabatic invariant (proportional to the ion magnetic moment), the second adiabatic invariant, and the ionic charge state distribution. No internal radiation belt helium ion sources were considered in this case, although that may be added in future refinements. The two simultaneous transport equations were solved in the finite difference representation using the method of stripped derivatives. Numerical iterations were carried out until the relative change, R=abs(F-Fold)/(F+Fold), in the iterated distribution function dropped below 10(-14), and then a full equilibrium test was carried out, computing the time derivative of the distribution function using a Salammbo-like method of forward time stepping. The latter test showed that an equilibrium solution had indeed been arrived at. The computed results yield helium ion phase space distribution functions for both ionic states in these variables, and these distributions have been converted to helium ion fluxes as functions of ion energy, pitch angle, Lshell and charge state. For geomagnetic equatorially mirroring ion, the results are characteristically similar to earlier results obtained with the purely three-dimensional model of Spjeldvik and Fritz (i. e., results in JGR, 1978), then carried out with a more limited matrix-solving technique without any anisotropy information. The present four-dimensional results demonstrate the magnetic latitude variations of the effects of helium ion "storage" in the higher charge state at energies in the MeV range and with subsequential charge exchange into the lower charge state. This yields a peculiar spatial distribution of He(1+) ions that would not be possible had the second ionic charge state not been attainable. Specifically, an equatorially centered secondary peak of He(1+) ions is computed at lower L-shells, between L=1.8 to L=3 at energies above 1 MeV. The "secondary production" of MeV He(1+) ions from He(2+) ions thus has modifying influence on the overall ion population. The results further suggest that even anisotropy characteristics of a heavy ion population can be indirectly modified by the charge exchange mechanism. The latter is because charge exchange processes are most rapid where the collisional exospheric environment has the greater density of collisional "targets".

Keywords: **radiation belt structure**, **modeling technique**, **energetic helium ions**, **charge states**

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