IMPLICATIONS OF SOURCE ABUNDANCES OF ULTRAHEAVY COSMIC RAYS

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1. Introduction. In this paper we will examine the ratio of cosmic-ray source abundance to solar-system abundance for individual elements. In particular we will look at correlations of these ratios with first-ionization potential (FIP) and also with the expected mass-to-charge ratio (A/Q) of the elements in a million-degree plasma. We have previously examined the FIP correlation and shown that the correlation is affected by the choice of C2 or C1 chondritic meteorites as the solar-system standard for comparison (Binns, *et al.*, 1984). An A/Q correlation was suggested by Eichler and Hainebach (1981), as a consequence of their model of shock acceleration in the hot interstellar medium, and has been examined by Israel (1985). These correlations are presented in the following four figures.

2. Explanation of Figures. Figure 1 plots the ratio of cosmic-ray source to solar-system abundances, normalized to unity for Fe, as a function of the first ionization potential. Error bars indicate the quadratic sum of the error on the solar-system abundance and that on the cosmic-ray source abundance. The element symbols for the various points have been transferred directly below the point.

Cosmic-ray source abundances in all four figures are derived principally from observations on HEAO-3, except for H and He which come from balloon observations (Webber, 1982; Webber and Lezniak, 1974). Two H points are plotted; H(R) uses H abundances at the same rigidity as the other elements; H(E), at the same energy per nucleon. For $6 \leq Z \leq 27$, and for $Z = 29$ and 31 (Cu and Ga), the results are from the Danish-French experiment on HEAO-3 (Lund, 1984). For $Z = 28$ and 30 (Ni and Zn) and for $Z \geq 32$ the results are from the Heavy Nuclei Experiment (Israel, *et al.*, 1983). In each case experimental results were propagated back to the source.in a standard leaky-box model.

In figures 1 and 3 the solar system abundances are from Anders and Ebihara (1982). These abundances are mainly from type C1 meteorites; except H, C, N, and O are from photospheric measurements, He is from the solar wind H/He ratio, Ne is from the solar wind Ne/Ar ratio and from astronomical measurements of extra-solar-system nebulae, and Ar, Kr, and Xe are interpolated from nearby elements. In figures 2 and 4 the C1 meteorite abundances are replaced by C2 meteorite abundances (Mason, 1979) in forming the solar-system values.

Figures 3 and 4 have the same ordinates as figures 1 and 2 respectively, but the abscissa is A/Q_{120}, where A is the atomic weight and Q_{120} is the charge state the element would have after removal of all electrons whose ionization potential is less than 120eV. Thus the abscissa is an estimate of the mass-to-charge ratio which the element would have in a million-degree interstellar gas. (The value 120 eV corresponds to a temperature of 1.4×10^6 K, but the correlation displayed here is insensitive to the precise value of ionization potential selected.)

The implications of these figures will be discussed at the conference.

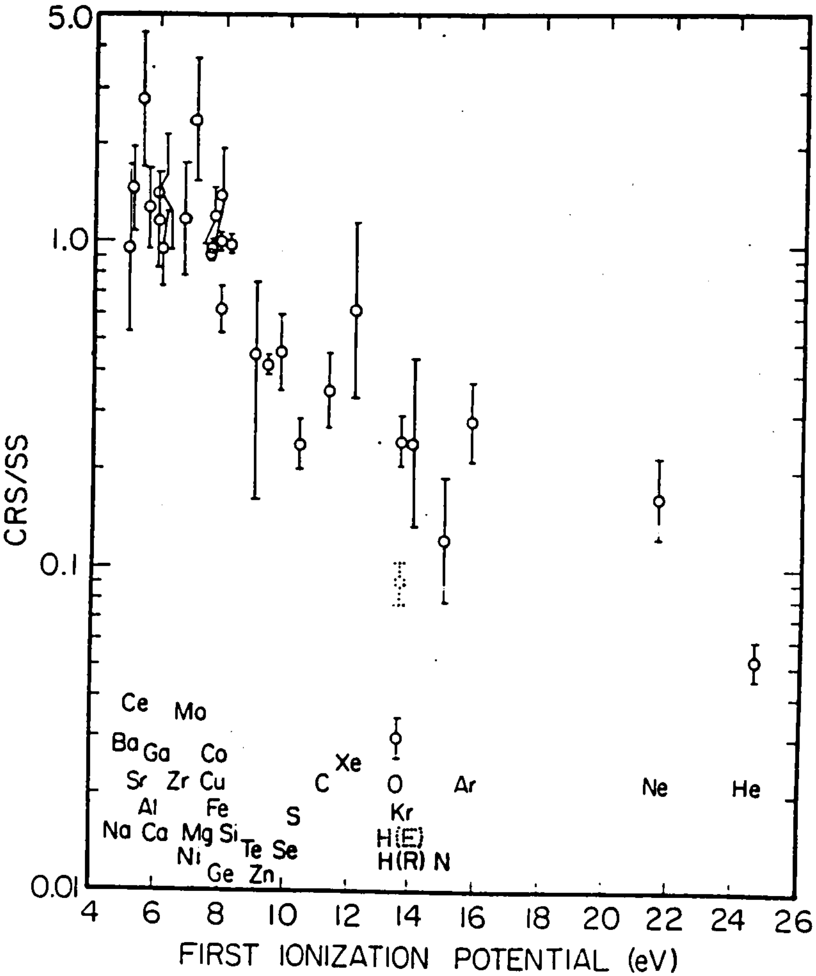

Figure 1

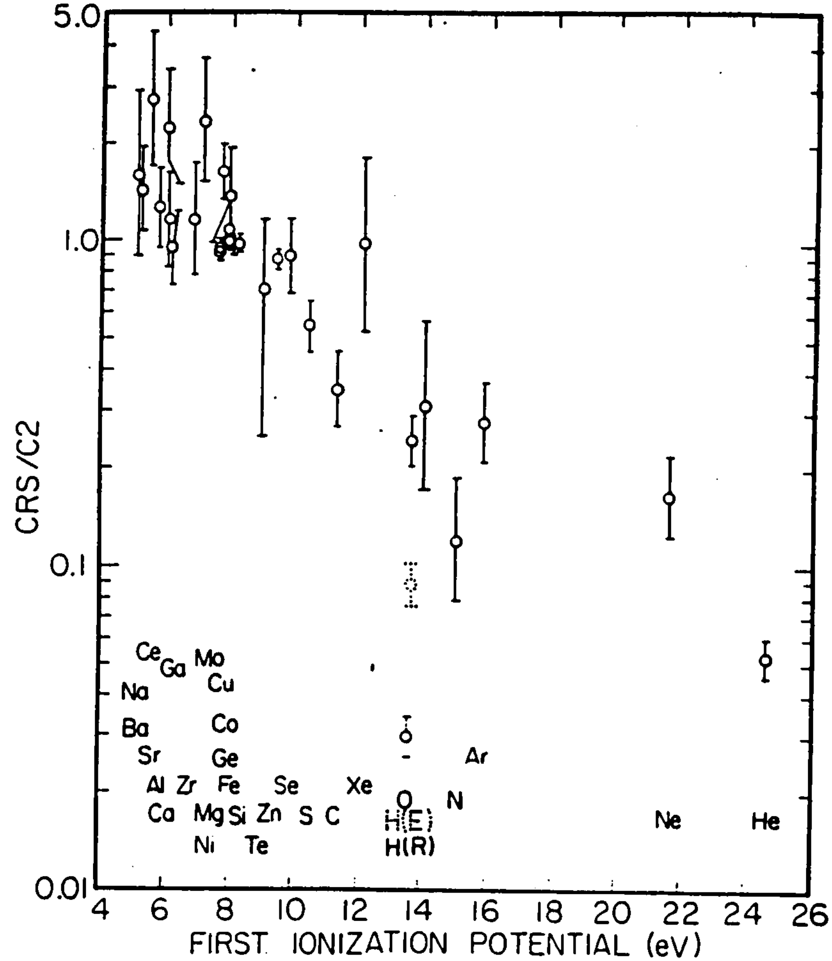

Figure 2

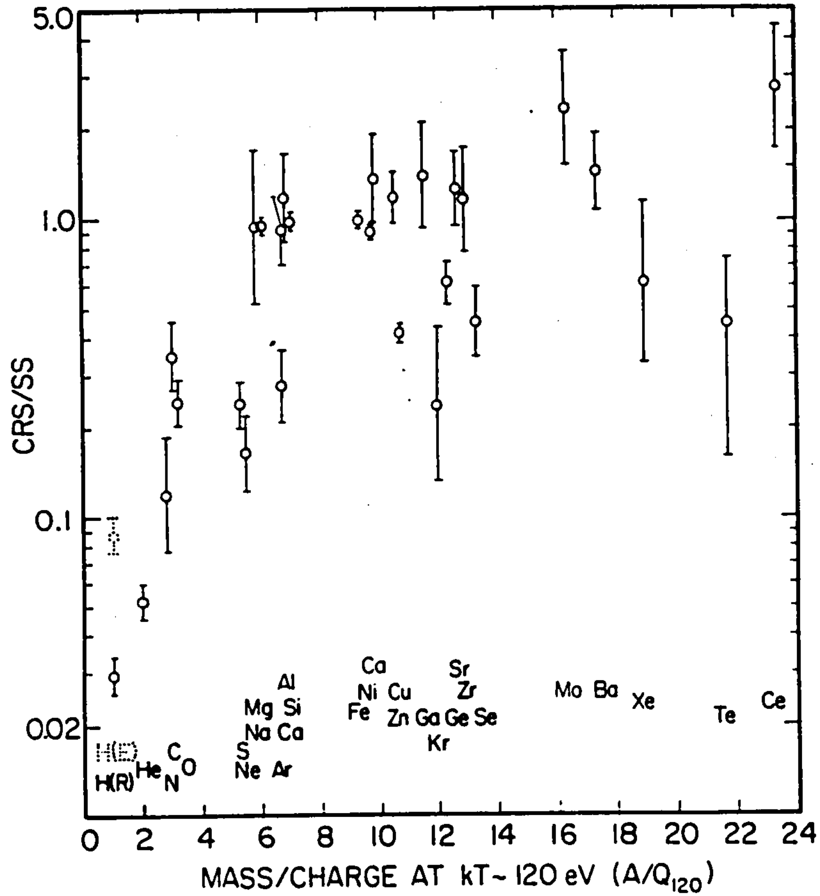

Figure 3

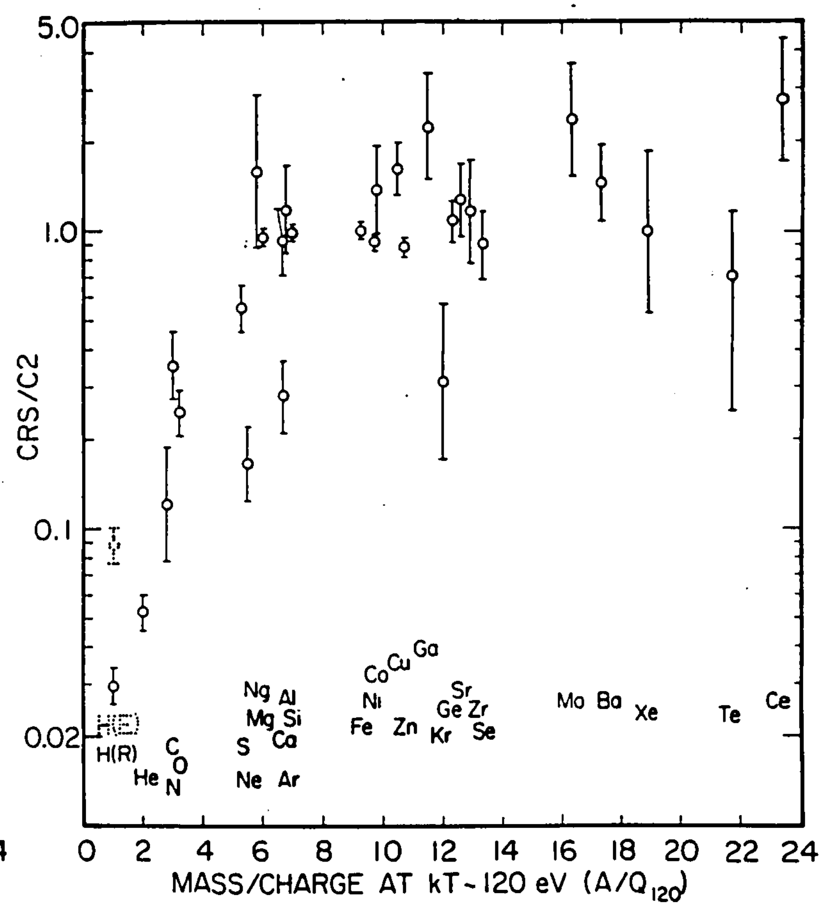

Figure 4

3. References.

Anders, E. and M. Ebihara, 1982, *Geochim. Cosmochim. Acta, 46,*, 2363.
Binns, *et al.*, 1984, *Adv. Space Res. 4,* (no. 2-3), 225.
Eichler, D. and K. Hainebach, 1981, *Phys. Rev. Lett. 47,* 1560.
Israel, M.H., 1985, *12th Texas Symp. Relativistic Astrophys.*, in press.
Israel, *et al.*, 1983, *18th ICRC, 9,* 305.
Lund, N., 1984, *Adv. Space Res. 4,* (no. 2-3), 5.
Mason, B., 1979, Geol. Survey Prof. Paper 440-B-1.
Webber, W.R., 1982, *Ap. J., 255,*, 329.
Webber, W.R. and J.A. Lezniak, 1974, *Ap. Space Sci., 30,*, 361.