Abstract

The results of general abundance studies, using the Copernicus satellite are reviewed. The general pattern of depletion of some elements such as Si, Al, Mn, Fe, and Mg, near the Sun is described. Techniques for obtaining abundances for various species are discussed, as are the aspects of the analysis which are uncertain. Variations in gas phase abundance from region to region are found for Fe and Si, similar to variations now known to exist for Ca and Ti based on visible spectra. A new generation of space instruments, with higher efficiency and resolution, in particular for 920 Å < λ < 1400 Å, can provide detailed interstellar line profiles, thus putting abundance determinations based on equivalent widths on a more firm footing, and yield more detailed information reflecting the make up and binding energies of interstellar dust particles as well as regional changes in the products of nucleosynthesis. The most important wavelengths and techniques relevant to these future studies are tabulated and discussed.

I. INTRODUCTION

Interstellar absorption measurements made with Copernicus have provided us over the last four years with a large amount of material on equivalent widths for the elements H, D, B, C, N, O, F, Mg, Al, Si, P, S, Cl, Ar, Cr, Mn, Fe, Ni, Cu, and Zn, as well as for several molecules. All of these species were previously not observed at sufficient resolution to guarantee freedom from stellar line blends for the equivalent width measures. Interstellar features with λ > 3000 Å, accessible from the ground, have very low abundances (Ti) or are trace ionization
stages, requiring additional knowledge of the electron density, $n_e$, to convert the
equivalent width measures to element abundances (Na I, Ca II, K I). Abundances
determined from equivalent widths of very weak lines are now known for several lines-
of-sight to an accuracy of better than 50%, and the corresponding H I column densi-
ties are known to an accuracy of 20% to 50% for over 100 stars. However, several
species suffer from saturation problems, so that various assumptions have to be made
in interpreting the equivalent widths and in evaluating the true uncertainties of
the determinations. I shall describe attempts to evaluate what assumptions should
be made, using in particular, observations of stars near the sun and of very distant
unreddened stars (§II), then summarize our present evaluation of the abundance pattern,
compared to the sun, and the interpretation of that pattern (§III). In §IV, I shall
summarize results on the abundances of interstellar species which might be forthcom-
ing using a new generation of space-borne equipment, using higher sensitivity and/or
resolution than that presently available. These measurements need to be as free as
possible from the ambiguities of saturation and line blends: the specific wave-
lengths are tabulated which will probably be the most useful. General conclusions
are stated in §V. Abundances of molecules, including $H_2$, and of isotope ratios
($D/H, ^{13}C/^{12}C$) are not covered in detail.

II. PRESENT PROBLEMS

Interstellar gas exists in a wide variety of physical conditions, with tem-
peratures ranging from $20^\circ$K to $\sim 10^6$K, and densities from $10^{-3}$ cm$^{-3}$ to $>10^5$ cm$^{-3}$. Most aggregates of gas are probably affected by mechanical energy input, in the
form of shock waves, as well as by radiation input, and by internal heating due
to chemical processes. Thus, the gas phase abundances of both atoms and molecules,
which we attempt to measure using well known laboratory transitions, may be expected
to undergo modification from time-to-time. There may be some "typical" grain type,
which is formed under conditions which can be reproduced at many points on a gal-
actic scale, such as atmospheres of M stars. The existence of such grains would
produce some characteristic absence of atomic species from the gas phase. Addi-
tional depletion may occur under selected conditions and be detectable in only