THE ENERGY DEPENDENCE OF THE NEON-22 EXCESS IN THE COSMIC RADIATION

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Introduction

It has been recognized now for some time that the heavy neon isotope, neon-22, is overabundant by a factor of 3 to 4 with respect to neon-22 in the cosmic ray source compared to the ratio of these isotopes in the Solar System (1-8).

In view of the otherwise remarkable similarity of the chemical composition of the cosmic ray source and the composition of the Solar Energetic Particles (9), the anomaly regarding the neon isotopes is so much more striking.

The observed excess of neon-22 is too large to be explained as a result of the chemical evolution of the Galaxy since the formation of the Solar System (10).

Further information on the origin of the neon-22 excess may come from a comparison of the energy spectra of the two neon isotopes. If the cosmic radiation in the solar neighborhood is a mixture of material from several sources, one of which has an excess of neon-22, then the source energy spectra of neon-20 and neon-22 may differ significantly.

Data

We have compiled the available data on the neon-22 to neon-20 ratio as function of energy. The data are shown in figure 1a. The observed ratio is sensitive to the level of solar modulation at the time of observation; therefore we show in figure 1b the same data extrapolated to zero solar modulation (the interstellar flux). We have used the force field approximation for the solar modulation and have applied a correction for each data point corresponding to the relevant period of observation.

Finally figure 1c shows the calculated source ratio corresponding to each data point. For this calculation we have used the propagation model described in (11).

The error bars in figure 1 are everywhere those of the experimenters. We have not attempted to assign errors to the correction for solar modulation or for the propagation calculation. The uncertainties in these corrections are appreciable despite the fact that we are only concerned with a flux ratio, not with absolute fluxes.

We note however, that the best fit straight line to the source fluxes has a slope of -0.031 ± 0.040, i.e. it is consistent with an energy

independent source ratio, even considering only the original statistical errors on the data points.

Discussion

The best fit, energy independent, source ratio of neon-22 to neon-20 is 0.35 ± 0.05. This is nearly three times the solar value of 0.12.

The apparent similarity of the source energy spectra for the two neon isotopes speaks in favor of a common acceleration mechanism for both, i.e. for the neon-22 excess already existing in the source material before the acceleration.

Since, as mentioned above, a neon-22 excess of the observed magnitude is unlikely to be a general feature of the present day interstellar medium, we are led to conclude that either there is a direct connection between the nucleosynthesis chain leading to excess neon-22 and the cosmic events leading to particle acceleration, or the local cosmic ray flux is dominated by a single source with an accidental excess of neon-22.

A dominance of a single source is incompatible with the observed high degree of isotropy of the cosmic radiation. The local source picture is therefore only tenable if restricted to the heavy nuclei; the bulk of the cosmic ray nucleons, in the hydrogen/helium component, must in any case arise in a multitude of sources distributed in the Galaxy (12).

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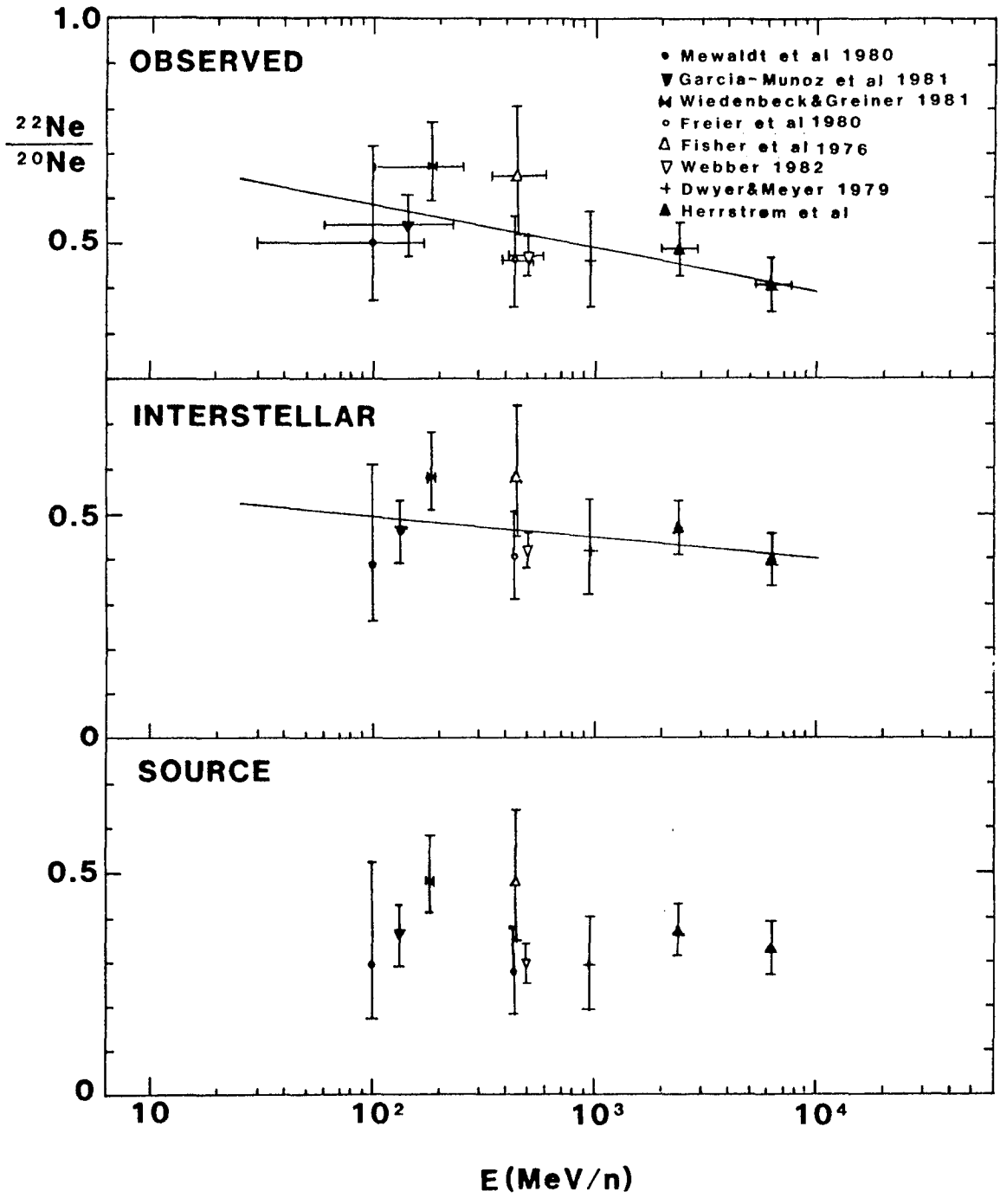

Fig. 1. The neon-22 to neon-20 ratio as function of energy.