Long-term variability of cosmic rays from meteorite observations

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"Short-term" variations in cosmic ray intensity during the last ~10^4 years related to heliospheric variability are recorded in terrestrial archives. The ^{14}C record or ^{10}Be in ice cores indicate that these have been on the order of a factor 2 to 3 (e.g., [1]). When it comes to variations on longer timescales (and exceeding that for variation of the geomagnetic field), information comes from terrestrial environments with very low erosion, and from meteorites.

Since they record interaction with cosmic rays on different timescales, key to the identification of variations is the comparison between the production of radionuclides with different halflives and comparison of radionuclides with stable products such as noble gas isotopes. Suitable terrestrial samples come from Antarctica, where rocks with surface exposure ages up to ~10 Ma can be found [2, 3]. "Minimum" exposure ages based on ^{26}Al ($T_{½}$ = 0.7. Ma), ^{10}Be ($T_{½}$ = 1.4 Ma) and stable ^{21}Ne are in essential agreement [3], providing no evidence for variations exceeding some 30 to 50%. A similar result is obtained from the study of stony meteorites, which typically have cosmic ray exposure (CRE) ages of some to some ten million years [4].

Cosmic ray intensity on very long timescales is recorded in iron meteorites, which should have "seen" the variation in cosmic ray flux associated with crossing the Milky Way's spiral arms [5, 6]. It has been argued that this is recorded in the distribution of iron meteorite CRE ages [5], but these are in need of re-evaluation, because in earlier work the production in iron meteorites of stable ^{21}Ne from target elements lighter than iron has been neglected [7]. Finally, it has to be noted that the ability of detecting variations depends on both, the size of the variations, and their duration in relation to the lifetimes of the radionuclides under consideration.

References

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