Improved ^{60}Fe Data: A Fingerprint of a Close-by Supernova 2.8 Myr Ago

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Several astropysical observations indicate that one or even more supernovae (SNe) occurred rather close (< 100 pc) to the solar system during the last millions of years. Such hints originate from studies of the local interstellar matter [1], analyses of the extreme ultraviolet radiation in the solar vicinity [2], observations of the composition of cosmic rays [3].

Such a nearby SN can be confirmed by the detection of SN produced material in a terrestrial reservoir. Because of their low terrestrial background, only long lived radionuclides seem to be suitable for this purpose. The radionuclide ^{60}Fe is especially well suited: It is produced inside the solar system only in minute amounts, whereas up to 10^{-4} solar masses of ^{60}Fe are created by a SN Typ II. Recently, decaying ^{60}Fe in our galaxy has been detected by the RHESSI satellite [4].

After the explosion, the ejected debris (containing the bulk of ^{60}Fe) can travel 50 pc and even beyond, depending on the density of the interstellar medium (ISM). In case of a SN sufficiently close to our solar system, this material can be directly deposited on Earth, leaving an ^{60}Fe signal far above the natural terrestrial level [5,6]. The half-life of 1.49 Myr is long enough to search for such a signal during the past several millions of years, and, the outstanding sensitivity of accelerator mass spectrometry (AMS) measurements at the GAMS setup allows the determination of ^{60}Fe/Fe ratios down to a level of 10^{-16} [7].

Ideal reservoirs for detecting such a signature are hydrogenous deep-ocean ferromanganese crusts. The analysis of three layers from a different crust had earlier provided the first indication of an ^{60}Fe enhancement [6]. Now we chose a crust (237KD from the cruise VA13/2) originating from the equatorial Pacific at a depth of 4830 m. Its growth rate of 2.5 mm/Myr was determined by the decrease of the concentration of the cosmogenic radionuclide ^{10}Be with the depth of a crust layer [8]. In this crust an ^{60}Fe depth profile has been measured. Layers with a thickness of 2 mm were milled of, iron has been extracted, and the ^{60}Fe/Fe ratio has been measured with AMS.

Because of the extremely low ^{60}Fe concentrations these measurements are time consuming. Even in the peak region ^{60}Fe count rates are in the order of one count per hour. First results have been reported in the annual report 2002 [9], already. The new, improved data are shown in figure 1. A 2 mm profile (wide horizontal error bars) shows a clear peak at 2.8 Myr and a weak enhancement at 9 Myr which could be attributed to SNe. Around these peaks measurement with improved depth resolution (1 mm or about 0.4 Myr) have been performed. The peak at 2.8 Myr could be clearly confirmed, at 9 Myr, however, the signal is now compatible with our background level of $2 \cdot 10^{-16}$.

The distance of the SN can be estimated to a few 10 pc (for more details see [10]), which is a very reasonable result: a much smaller distance is very unlikely and should have left additional marks on Earth, whereas for a much larger distance the explosion front would have been stopped by the ISM before it would have reached the Earth.

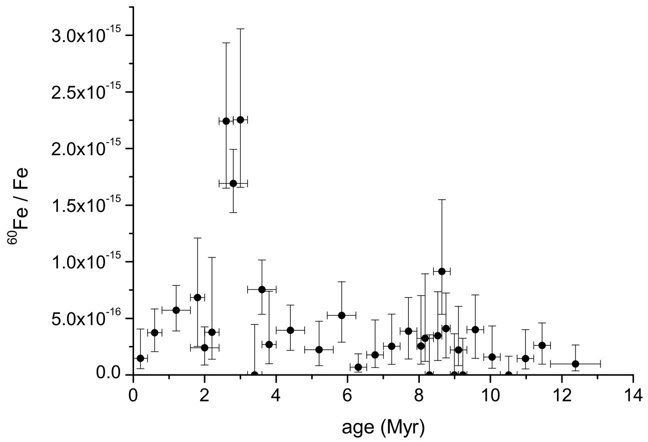

Fig. 1: ^{60}Fe/Fe ratios in the maganese crust versus the age of the layer. Vertical error bars give the statistical error with a CL of 68.3 %, horizontal bars indicate the depth (time) intervals covered by the respective layers.

References

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