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^{60}Fe and ^{244}Pu on Earth – Access to the Solar Neighbourhood, Stars and the Past of Earth

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Long-lived radionuclides such as ^{60}Fe ($t_{1/2}$=2.6 Myr) or ^{244}Pu ($t_{1/2}$=81 Myr) are synthesised in significant quantities in stellar environments by the capture of free neutrons. ^{60}Fe is in addition also produced, by cosmic ray interactions with interplanetary bodies, albeit at much lower quantities. Importantly, on Earth natural production of both isotopes is negligible, making them a valuable tracer of extraterrestrial origin. Since these two isotopes are synthesised by the slow neutron-capture process (s-process) and predominantly ejected in supernovae, and the rapid neutron-capture process (r-process), respectively, the potential detection of both isotopes opens the possibility to connect both processes in one astrophysical production site. The only measurement technique at this time which is sensitive enough to measure lowest concentrations of both isotopes is Accelerator Mass Spectrometry (AMS).

[1] History of detecting extraterrestrial ^{60}Fe

Extraterrestrial ^{60}Fe was detected first on Earth in a ferromanganese crust by the Munich AMS group in 2004 [1,2]. These samples allowed to analyse the past ~10 Myr for its ^{60}Fe content. Time-profile and absolute influx indicate that these ^{60}Fe atoms in the deep-sea crust were produced and ejected by one or more supernovae about 2 to 3 Myr ago and subsequently incorporated in this geological archive.

This discovery triggered several other projects to confirm this finding and to look for the same signal in other reservoirs like deep-sea sediments [3,4].

Furthermore, ^{60}Fe was also discovered on the Moon in lunar regolith [5].

These measurements all point towards an interstellar ^{60}Fe entry about 2-3 Myr ago, but the signal weakens and approaches measurement background for recent times. However, such ^{60}Fe measurements are extremely difficult and only two AMS facilities (TU Munich and ANU) are sensitive enough for such measurements. For these reasons, also no significantly enhanced extraterrestrial influx of contemporary ^{60}Fe (i.e. within the last few 10 kyr) on Earth could be reported.

[2] ^{60}Fe in Antarctic snow

AMS is a relative measurement for isotope ratios, here extraterrestrial ^{60}Fe relative to stable terrestrial Fe. One major problem in the detection of modern ^{60}Fe influx from space by AMS, is presence of the highly abundant stable terrestrial iron. Combined with the short ^{60}Fe accumulation periods, detection of a recent extraterrestrial signal becomes extremely challenging. To overcome this limiting factors, 500 kg of pure Antarctic surface snow (i.e. with lowest terrestrial Fe content) were recovered from the Kohnen Station in Antarctica and chemically processed for an AMS measurement.

Indeed, ^{60}Fe was discovered in Antarctic snow and by comparison with other isotopes such as ^{53}Mn, which is dominantly produced by cosmic ray interactions with solar system objects, the origin of these ^{60}Fe atoms could be deduced [6].

[3] Search for concomitant ^{60}Fe and ^{244}Pu influx onto Earth

Recently, we have started a project to extend previous measurements of ^{60}Fe and ^{244}Pu in several geological reservoirs. The search for the coincident influx of ^{60}Fe and ^{244}Pu into the same terrestrial archive opens the possibility to investigate a connection between Supernova-signatures (^{60}Fe production) and *r*-process nucleosynthesis (^{244}Pu is a pure *r*-process nuclide). For this purpose, compared to previous studies [2,7], a substantially larger sample of the same ferromanganese crust is available for ^{60}Fe [2] and ^{244}Pu [7]. In this multi-isotope approach, we aim for a detailed time-profile for both isotopes in the crust. Such a project has become feasible also due to a substantially improved detection efficiency in ^{244}Pu measurements. In addition, we plan to extend the time-period further into the past.

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