

Titanium (Ti) has five stable isotopes:  $^{46}\text{Ti}$ ,  $^{47}\text{Ti}$ ,  $^{48}\text{Ti}$ ,  $^{49}\text{Ti}$  and  $^{50}\text{Ti}$ , which comprise 8.0, 7.3, 73.4, 5.5 and 5.4% of solar Ti respectively. Titanium-48 is the most abundant. Like for the other  $\alpha$ -enhanced elements, the observed abundance of Ti in stars of our Galaxy does not scale with the metallicity of the star, but  $[\text{Ti}/\text{Fe}]$  rather decreases with increasing  $[\text{Fe}/\text{H}]$ , from 0.5 at  $[\text{Fe}/\text{H}] < -2$  to 0 at  $[\text{Fe}/\text{H}] = 0$ . When current theoretical models of nucleosynthesis in Type II Supernovae (SNII) [2] are used to compute the Galactic Chemical Evolution (GCE), this trend is not explained, as clearly displayed in Figure 27 of [1]. The nucleosynthetic origin of the other Ti isotopes also presents major problems: Figure 28 of [1] shows that  $^{47}\text{Ti}$  and  $^{50}\text{Ti}$  are strongly underproduced by SNIIE, by about a factor of 5, with respect to solar abundances. The solar abundances of these two Ti isotopes have been reproduced, within a factor of two, by including contributions from different kinds of Supernovae of Type Ia (SNIa) [3, see their Figure 2).

Ti isotopic ratios have been measured in meteoritic presolar SiC grains that originated in the envelopes of Asymptotic Giant Branch (AGB) stars [4,5]. Such measurements can help in understanding the cosmic origin of Ti because, as for Si, Ti isotopic ratios in SiC are mainly determined by the initial composition of the grains' parent stars. These measurements are shown in Figure 1 as permil variations relative to the abundant  $^{48}\text{Ti}$  and to solar, as functions of the  $^{46}\text{Ti}/^{48}\text{Ti}$  and the  $^{29}\text{Si}/^{28}\text{Si}$  ratios. Weak to strong correlations, already noted by [4], can be found in all panels of Figure 1.

Local inhomogeneities in the interstellar medium have been found by [6] to offer an explanation, possibly concurrent with GCE, of the spread of Si isotopic ratios observed in SiC. Using the method of [6] we performed a test for the Ti isotopic ratios that consisted of randomly adding contributions from different kinds of SNe to material of initial solar composition. The results are shown in Figure 1. Relative to what had been done for Si [6], the most important variation has been the addition of the contribution from a rare type of SNIa, which is necessary for the production of  $^{50}\text{Ti}$ . We furthermore multiplied the SNII yields of  $^{47}\text{Ti}$  by a factor of 5. Neutron capture ( $s$  process) in AGB stars can modify the Ti abundances, particularly those of the neutron-rich isotopes  $^{49,50}\text{Ti}$ . In our test we added a constant  $s$ -process contribution to the Si and Ti ratios, as predicted for a  $1.5 M_{\odot}$  star with a standard amount of the main neutron source  $^{13}\text{C}$  (see Figure 5 of [6]).

The resulting predictions, in some cases, cover a larger range than the grain data and, especially for the Ti vs. Si plots, do not show the same degree of correlation. However, large uncertainties are associated both with the SN yields and the  $s$ -process contributions. The latter include large uncertainties in the Ti neutron capture cross sections (see Table 1 of [6]). Moreover, the data are presently quite limited and suffer from problems of non-random selection of grains. Further developments are expected, since Si and Ti isotopic measurements of superior quality on many randomly selected grains will be made with the new NanoSIMS ion microprobe.

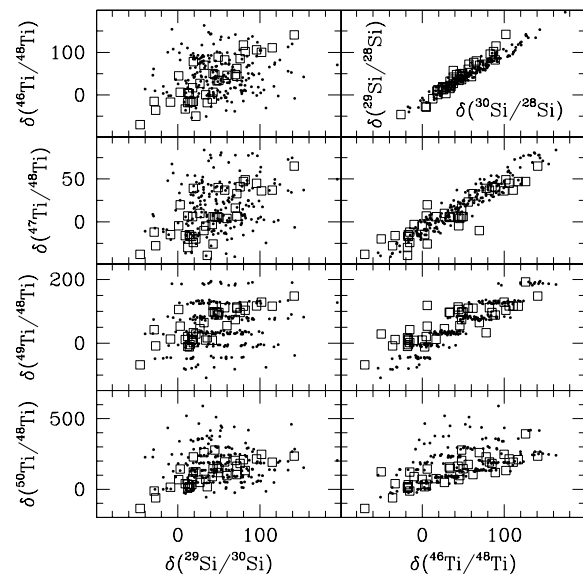


Figure 1: Ti and Si isotopic ratios expressed as permil deviations from the solar ratios ( $\delta$  values). Measurements are open squares and predictions are black dots.

- References** [1] Timmes F.X. et al. (1995) *Astrophys. J. Suppl.*, 98, 617. [2] Woosley S.E. and Weaver T.A. (1995) *Astrophys. J. Suppl.*, 101, 181. [3] Woosley S.E. et al. (1997) *Nucl. Phys.*, A621, 445c [4] Hoppe P. et al. (1994) *Astrophys. J.*, 430, 870. [5] Alexander C. M. O'd. and Nittler L. R. (1999) *Astrophys. J.*, 519, 222. [6] Lugaro M. et al. (1999) *Astrophys. J.*, 527, 369.