Session 1: Plasma and Fresh Nucleosynthesis Phenomena

1-2. Supernovae, Supernova Remnants and Galactic Hot Plasma

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THE HALF-LIFE OF TITANIUM 44 AND SN 1987A

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The radioactive isotopes, such as ^{44}Ti and ^{56}Ni, are synthesized as a result of rapid nucleosynthesis in supernova explosions. The gamma-ray photons coming out from the decay sequence of ^{44}Ti is now a strong candidate to explain the the late light curve of SN 1987A. It is noted here that the energy release from the ^{44}Ti decay depends strongly on its half-life. However, the published values for ^{44}Ti half-life display a large spread, ranging from $\sim$ 35 to $\sim$ 68 years. In this paper (Kumagai et al. 1997; see also Kumagai et al. 1993), we discuss the value of the half-life by comparing the theoretical light curves and the observations in SN 1987A. The unestablished half-life value is related to the ratio of the abundance of ^{44}Ti to that of ^{56}Ni.

In Figure 1, we show the ranges of $<^{44}\mathrm{Ti}/^{56}\mathrm{Ni}>$ which satisfy the observed luminosity integrated from the infrared to the ultraviolet wavelength as the function of the half-life of ^{44}Ti. In this figure, the region sandwiched between the two dotted lines accounts for the late luminosity of SN 1987A derived by the combined observations of CTIO and HST at 3600 days after the explosion (Suntzeff 1997). On the other hand, the wider region between the two dashed lines in Figure 1 satisfies the luminosity observed with CTIO at 1699 days after the explosion (Suntzeff 1997). Here, we define $<^{44}\mathrm{Ti}/^{56}\mathrm{Ni}>$ as the ratio of $^{44}\mathrm{Ti}/^{56}\mathrm{Ni}$ (in amounts) in the supernova remnant to $^{44}\mathrm{Ca}/^{56}\mathrm{Fe}$ in the solar neighborhood, i.e., $<^{44}\mathrm{Ti}/^{56}\mathrm{Ni}> \equiv [X(^{44}\mathrm{Ti})/X(^{56}\mathrm{Ni})]/[X(^{44}\mathrm{Ca})/X(^{56}\mathrm{Fe})]_{\odot}$. Note that ^{44}Ca and ^{56}Fe are the daughter nuclei of ^{44}Ti and ^{56}Ni, respectively.

K. Koyama et al. (eds.), The Hot Universe, 241-242.

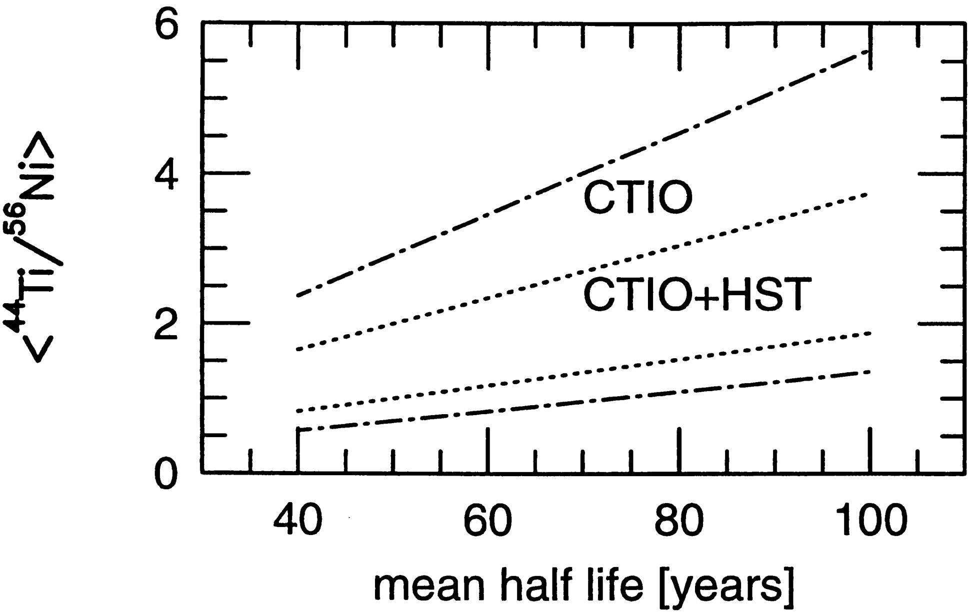

Figure 1. The ranges of <^{44}Ti/^{56}Ni> which satisfy the late observed luminosity in SN 1987A are shown against the half-life of ^{44}Ti.

One sees in Figure 1 that the overall range of the published values of the half-life mentioned above is appropriate to explain the late observed luminosity (abbreviated by CTIO+HST), if <^{44}Ti/^{56}Ni> is roughly in between 1 and 2. If we assume <^{44}Ti/^{56}Ni>= 1, Figure 1 shows that the real half-life value of ^{44}Ti is larger than $\sim$ 45 years but is less than $\sim$ 55 years, taking the $\sim$ 10% uncertainty of the solar abundance measurements into account. Contrarily, it is quite interesting to note that we can deduce the value of ^{44}Ti/^{56}Ni in SN1987A from this figure, if the real half-life of ^{44}Ti is established experimentally.

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