The Lightcurve of SN 1987A Revisited: Constraining Production of Radioactive Nuclides

The set of radioactive parent isotopes that have been used to model the nuclear decay energy source terms for the light curve of SN 1987A are ^{22}Na, ^{44}Ti, ^{56}Ni, ^{57}Ni and ^{60}Co. Recently, it was shown that heating by internal conversion and Auger electrons emitted during the decay of ^{57}Co and Auger electrons produced in the decay of ^{55}Fe can be the dominant channels for the light curves of thermonuclear supernovae. In this effort, we re-evaluate the light curve of SN 1987A, taking into account these previously neglected decay channels.

First, we show the V-band luminosity constitutes a roughly constant fraction of the bolometric luminosity between 900 and 1900 days, and we obtain an approximate bolometric light curve out to 4334 days by scaling the late time V- band data by a constant factor where no bolometric light curve data is available. Considering ^{44}Ti, ^{55}Co, ^{56}Ni, ^{57}Ni, and ^{60}Co, we perform a least squares fit to the constructed composite bolometric light curve. For the nickel isotopes, we obtain best fit values of $M(^{56}Ni) = (7.1 \pm 0.3) \times 10^{-2}\ M_\odot$ and $M(^{57}Ni) = (4.1 \pm 1.8) \times 10^{-3}\ M_\odot$. Our best fit ^{44}Ti mass is $M(^{44}Ti) = (0.55 \pm 0.17) \times 10^{-4}\ M_\odot$,which is in disagreement with the much higher $(3.1 \pm 0.8) \times 10^{-4}\ M_\odot$ recently derived from INTEGRAL observations.

We also find that the leptonic channels in the decay of ^{57}Co (internal conversion and Auger electrons) are a significant contribution and constitute up to 15.5% of the total luminosity. Consideration of the kinetic energy of these electrons is essential in lowering our best fit nickel isotope production ratio to $[^{57}Ni/^{56}Ni] = 2.5 \pm 1.1$, which is still somewhat high but in agreement with gamma-ray observations and model predictions.

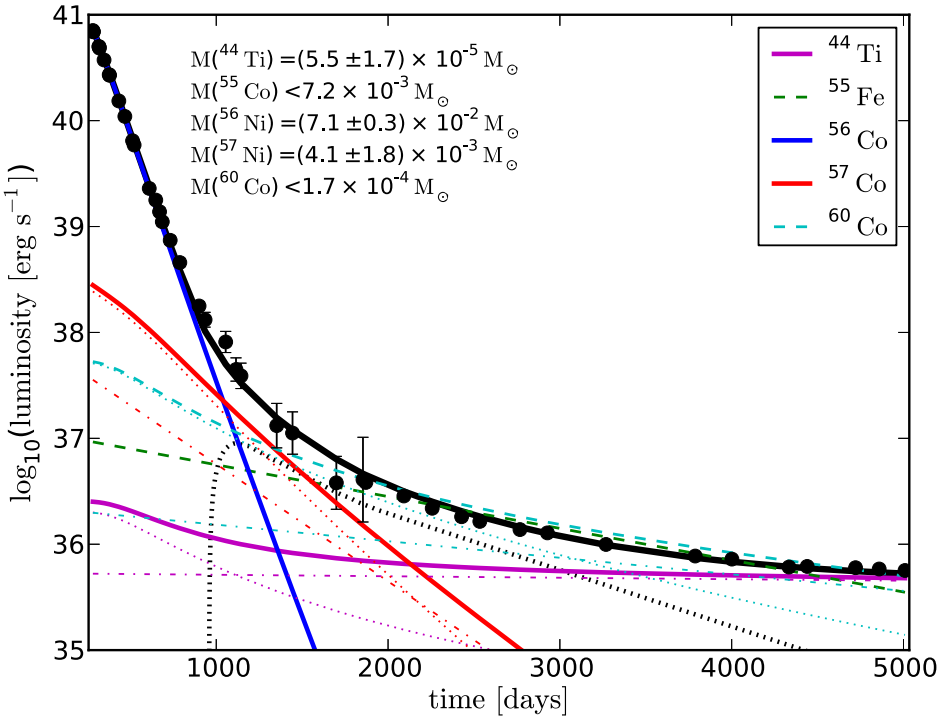

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Fig 1 - Model light curve (thick black line) including our time-dependent freeze-out correction (black dashed line). This light curve is the result of a five component least squares fit of initial abundances of ^{44}Ti, ^{56}Ni, ^{57}Ni, ^{55}Co and ^{60}Co on the composite bolometric light curve. The γ-ray contributions for each nuclide are shown with dotted lines and electron and positron contributions are shown with dot-dashed lines. The best fit values of ^{55}Co and ^{60}Co are significantly smaller than their respective uncertainties, which we show as upper limits for these isotopes.