On Silicon Group Elements Ejected by Supernovae Type Ia

Type Ia supernovae are thought to be the evolutionary terminus for a class of binary stellar systems, the thermonuclear incineration of one or more carbon-oxygen white dwarfs, an element factory for the production of iron-group elements, accelerators of cosmic rays, sources of kinetic energy in galaxy evolution, and useful tools for measuring cosmological parameters. There is compelling evidence that the peak brightness of a Type Ia supernova is affected by the composition at the time of the explosion. To date, determining the composition of the progenitor has relied on indirect proxies, such as the average metallicity of the host stellar population.

In this work, we suggest the electron fraction, Ye, of the progenitor white dwarf systematically influences the nucleosynthesis of silicon group ejecta. We suggest that the abundances generated in quasi nuclear statistical equilibrium (QNSE) are preserved after the explosion. This allows one to potentially recover Ye from the abundances of observed spectra.

We show that measurement of the ^{28}Si, ^{32}S, ^{40}Ca, and ^{54}Fe abundances can be used to construct Y_e in silicon-rich regions of the supernovae. These four abundances are sufficient to recover Y_e to within 6% because these four isotopes dominate the QNSE composition. Analytical analysis shows the ^{28}Si abundance is insensitive to Y_e, the ^{32}S abundance has a nearly linear trend with Ye, and the ^{40}Ca abundance has a nearly quadratic trend with Ye. We verify these trends with post-processing of 1D supernovae type Ia models and show that these trends are reflected in the model's synthetic spectra.

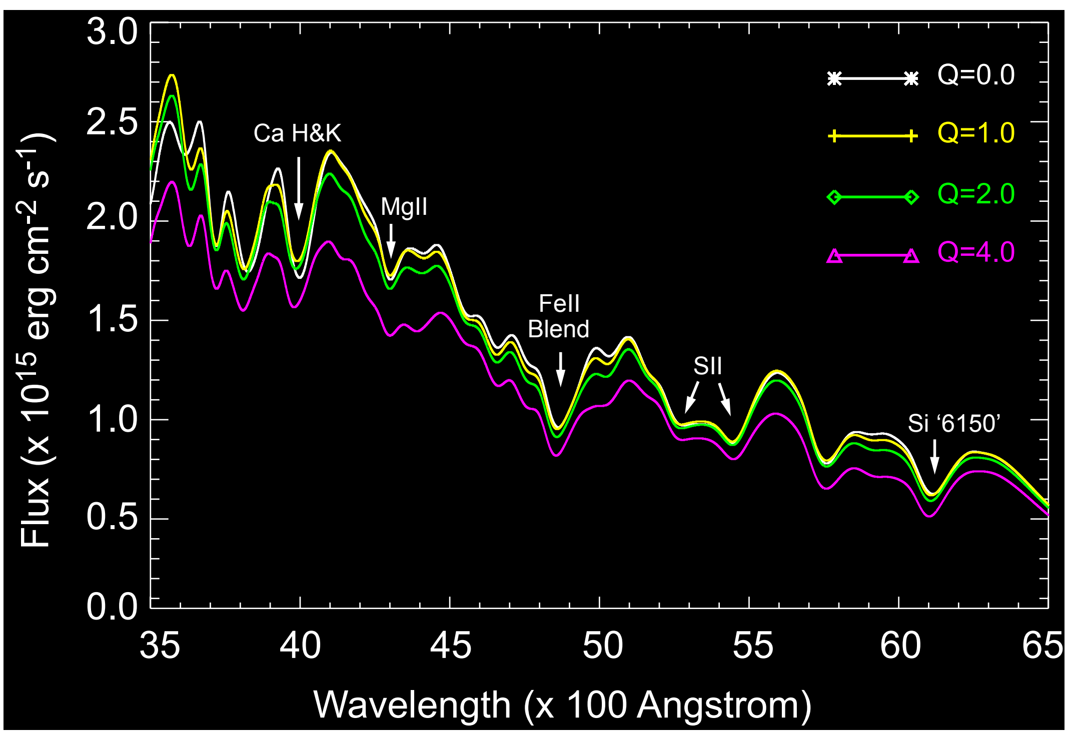

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Fig 1 - Spectra for W7-like models with 0.0. 1.0, 2.0, and 4.0 times the solar ^{22}Ne abundance. The main silicon, sulfur, magnesium, and iron features at peak luminosity are labelled.