

ON THE ORIGIN OF ^{22}Na IN Ne-E(L).

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Introduction: Ne-E(L) is carried by presolar graphite grains with a range of density (1.6–2.2 g/cm³) [1]. The ^{22}Ne in Ne-E(L) was long thought to come from the decay of ^{22}Na ($T_{1/2} = 2.6$ a). Although a dominant source of ^{22}Ne is ^{22}Na , a portion of the ^{22}Ne is ^{22}Ne produced in asymptotic giant branch (AGB) stars and proportions of ^{22}Ne from the two origins vary with density [2]. In the case of low-density graphite grains (1.65–1.72 g/cm³) from Murchison, all the ^{22}Ne originated from ^{22}Na produced in supernovae, not in novae [3]. Here we further examine the origin of ^{22}Na in higher-density separates from Murchison.

Discussion: There are two stellar sources for ^{22}Na . In type II supernovae it is produced in the O/Ne zone during hydrostatic C burning by $^{21}\text{Ne}(p,\gamma)^{22}\text{Na}$, where ^{21}Ne is produced by $^{20}\text{Ne}(n,\gamma)^{21}\text{Ne}$ and protons by $^{12}\text{C}(^{12}\text{C},p)^{23}\text{Na}$ [4, 5]. In novae, ^{22}Na is produced via $^{20}\text{Ne}(p,\gamma)^{21}\text{Na}(\beta^+\nu)^{21}\text{Ne}(p,\gamma)^{22}\text{Na}$ that requires $T \sim 4 \times 10^8$ K. Therefore, ONe novae, more massive than CO novae, can reach higher peak temperatures, have higher ^{22}Na yields [(3.1 – 65) $\times 10^{-5}$ in ONe novae; (8.5 – 34) $\times 10^{-8}$ for CO novae, in mass fraction] [6].

A difficulty to explain ^{22}Na in presolar graphite by nova origin is that Ne is much more abundant than ^{22}Na in both types of novae: $^{20}\text{Ne}/^{22}\text{Na}$ ratios range from 406 to 11,300 [6]. In addition, although $^{20}\text{Ne}/^{22}\text{Ne}$ ratios expected for CO nova ejecta are low (0.07 to 0.72), those for ONe novae, which are a proficient producer of ^{22}Na , are rather high (37 to 2,890) [6]. Therefore, if graphite grains contain ^{22}Na from novae, ^{22}Na must have been incorporated into the grains in an environment where Ne could be totally eliminated during the grain formation and/or in the subsequent stage.

Supernovae pose a similar situation. In the O/Ne zone in a $25M_{\text{sun}}$ star with solar metallicity, the ^{22}Na yield is estimated to be 1.89×10^{-6} (in mass fraction) and the $^{20}\text{Ne}/^{22}\text{Na}$ ratio is 1.14×10^5 [4]. However, in the case of supernovae, implanted Ne into the grain surface is likely to be removed after grains encounter the reverse shock. Infrared observations of Cassiopeia A indicate that nucleosynthetic zones are associated with characteristic dust to the zones [e.g., 7], indicating that relative velocities between the dust and the gas are relatively small. A relative velocity between grains and the gas (Ne), estimated from the amorphous rims of TiC subgrains in low-density graphite [8], is ~ 300 km/s. Using this velocity, Ne would be implanted into 25 nm down the grain surface [3]. The layer of this thickness is very likely to be sputtered when grains travel into the hot H-rich outer zones and into the ISM (interstellar medium) after the reverse shock reaches nucleosynthetic zones, causing decoupling of the grains and the gas [9]. Whether the same scenario works for nova ejecta remains to be seen: there are no observations or theoretical work that access the interaction between the nova ejecta and the ISM yet.

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