GALACTIC EVOLUTION OF NRLEE DUST

B. S. Meyer[1] and K. R. Bermingham[2], [1]Department of Physics and Astronomy, Clemson University, Clemson, SC 29634 USA (mbradle@clemson.edu), [2]Department of Earth and Planetary Sciences, Rutgers University, Piscataway, NJ 08854 (kb1012@eps.rutgers.edu).

Introduction: Isotopic anomalies in neutron-rich iron-group isotopes may be carried into the Solar System by dust from Neutron-Rich, Low-Entropy matter Ejectors (or NRLEEs) [1]. NRLEEs are probably thermonuclear electron-capture supernovae [2], which are likely the dominant source of ^{48}Ca in the Solar System [3]. NRLEEs produce significant enrichments in the neutron-rich iron-group species in their innermost oxygen-poor regions but, due to the relatively low explosion energy of the event, also eject a considerable abundance of unburned ^{16}O in more exterior regions of the exploding star. Mixing between these layers likely produces oxide dust that carries strong enrichments in neutron-rich iron-group species, and oxide grains have been observed in the meteorite record with such enrichments [4]. Those grains are plausibly from NRLEEs [2].

NRLEE Dust Evolution: NRLEE dust enters the interstellar medium (ISM) and joins other stellar condensates and ISM dust. Sputtering and shattering processes then destroy grains and re-accretion builds dust back up. The dust built up by re-accretion (the ISM dust) is significantly less anomalous than the stellar condensates because that dust is a mix of the previously destroyed stellar condensates. The Solar System inherits this mix of dust, so the possible range of isotopic anomalies that could result from this dust depends on the degree of anomalies present in the stellar condensates and their contribution to the total dust in the Solar System.

We have constructed models of the evolution of dust from NRLEE events and other stellar events. Given typical dust destruction times of roughly 100 Myr, the models show that the mass of the NRLEE dust is about 10^{-5} to 10^{-4} of the total non-anomalous dust mass, although that fraction can vary by up to two orders of magnitude due to the fact that NRLEE events are rare, so the NRLEE dust abundance in the ISM fluctuates based on how recently a NRLEE event occurred in the local region.

Expected Anomalies: Our NRLEE models suggest that the dust could be enriched in neutron-rich iron-group isotopes by factors of roughly 100 [2], which in agreement with enrichments seen in the putative NRLEE grains observed by Nittler and collaborators [3,4]. Combined with a level of NRLEE dust mass to non-anomalous dust mass of ~10^{-5} to 10^{-4}, one could expect anomalies from extremely inhomogeneous mixtures of NRLEE dust as large as one part in 10^2 to 10^3. Less extreme inhomogeneous mixtures could explain observed anomalies, which are of order a few parts in 10^4 [2,5].

Our predicted anomalies depend on details of the model. In particular, the predicted anomalies depend on 1) the frequency of NRLEE events, 2) the composition of the ejected NRLEE dust, and 3) the timescale of dust destruction and re-accretion processes in the ISM. They also depend on the degree of inhomogeneous distribution and processing of NRLEE dust in the proto-planetary disk. These are all details we are exploring further with quantitative models.

References: [1] Bermingham K. R. et al. (2022) *GCA,* in review. [2] Jones S. et al. (2019) Astron. Astrophys. 622, A74. [3] Jones S. et al. (2019) Astrophys. J. 882, 2. [4] Nittler L. et al. (2018) Astrophys. J. 854, L24. [5] Niemeyer S. (1988) *GCA* 52, 309-318.