Bringing back core-collapse supernova explosions as r-process site

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Canonical core-collapse supernova explosions, driven by the neutrino-heating mechanism, are presently ruled out as nucleosynthesis site for the production of heavy elements. Detailed numerical studies, with accurate neutrino transport and a sophisticated treatment of weak processes included, have shown that the ejected material does not yield sufficient neutron excess [1] for the production of elements with atomic numbers greater than $32 < Z < 50$ [2], known as light neutron-capture elements. Here, we will review this caveat in the light of observations of metal-poor star (metalicity as stellar age tracer), dwarf galaxies and deep sea sediments. Based on new insights, we revisit the possibility that a few rare supernova explosion events can account for a strong r-process, i.e. the production of elements up to mass numbers of $A \simeq 195$ (third r-process peak). Therefore, it has been shown recently that the appearance of exotic phases of hot and dense matter, associated with a $1^{\rm st}$-order phase transition from ordinary nuclear matter to the quark-gluon plasma at the supernova interior, triggers the onset of energetic supernova explosions of massive stars with zero-age main sequence masses of 40–50 $M_\odot$ [3]. Moreover, these events yield a strong r process, which we will present and discuss here for the first time.

Keywords: core-collapse supernovae – equation of state – nucleosynthesis

References

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