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Gamma rays as an indicator of nucleosynthesis[1]

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In 1957 the collaboration of E. M. Burbidge, G. R. Burbidge, W. A. Fowler, and F. Hoyle, and the work by A. G. W. Cameron, laid the foundations for understanding the origin of the elements in terms of a few basic processes and astrophysical environments. Half a century after this pioneering work, there is considerable observational evidence for the basic notions of element synthesis during the big-bang, followed by hydrostatic and explosive stellar nucleosynthesis ever since the first population of stars re-illuminated the Universe, and through particle interactions in the turbulent interstellar medium. In 1969 D. D. Clayton, S. A. Colgate, and G. J. Fishman proposed to search for gamma-ray lines from the decay of 56-Ni, freshly synthesized in supernovae. Evidence for these lines was obtained for SN 1987A, and three decades after this pivotal supernova we have ample gamma-ray line evidence for ongoing nucleosynthesis in the Milky Way from surveys for individual sources and unresolved, integrated diffuse emission from an ensemble of such sources. We review the observational evidence for gamma ray lines from various species, and discuss the astrophysical implications of detections and a few puzzles suggested by lack of detections. We reflect on historic developments, assess the accomplishments, and present an outlook on the future of this branch of nuclear astrophysics.

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