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Neutron Capture Nucleosynthesis In Asymptotic Giant Branch Stars

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This paper presents a general review of the Asymptotic Giant Branch (AGB) evolutionary stages for Low and Intermediate Mass Stars and of the nucleosynthesis processes occurring in them, chiefly as a consequence of the activation, in their final phases, of two crucial neutron-releasing reactions, 13 C(a,n) 16 O and 22 Ne(a,n) 25 Mg. These are jointly responsible for the production of most of the heavy nuclei generated through slow neutron captures, i.e. the so-called s-process, where neutron additions on unstable isotopes close to valley of beta-stability occur on average less effectively than the corresponding weak interactions (mainly b - decays). In particular, AGB stars are recognized to produce almost entirely s-process nuclei in the range from A ~ 85 (Kr, Rb, Sr) to A ~ 208-209 (Pb, Bi), i.e. the so-called Main Component of the s-process, as observed in our Galaxy, together with variable contributions to lighter species. As this field has been active now for almost 70 years and has seen the gradual development of our knowledge of the basic nuclear mechanisms and the parallel growth in our understanding of the stellar models for those advanced evolutionary stages, part of this review is dedicated to the historical progresses in these fields.
More modern approaches encountered significant difficulties, hampered as they were by our poor understanding of stellar (especially non-convective) mixing mechanisms. This peculiarity will require therefore some a non-marginal mention. Decisive improvements finally came jointly by gradually more precise observational constraints and by increasing accuracy in the determination of neutron capture cross sections. They both induced the understanding of 13 C(a, n) 16 O as the dominant neutron releasing reaction for the production of heavy s-nuclei. I then proceed to account for (some) contributions coming from various research groups to the improvements of the present century, both on mixing mechanisms and on less-widely parameterized approaches, which now seem to yield a rather comprehensive view of the subject and to the establishment of the first credible constrains on the r- (and possibly i-) processes, complementing the synthesis of heavy nuclei.

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