Slow neutron captures as the signature of AGB stars

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Asymptotic giant branch (AGB) stars evolve from stars of masses roughly lower than ten solar masses and produce many of the cosmic abundances of the chemical elements, including C, N, and F. One of their main characteristic signatures is the production of roughly half of the abundances of the elements heavier than Fe via slow neutron captures (the s process). At the end of the last century, significant progress in stellar modelling, combined with the availability of nuclear physics inputs, allowed us to successfully predict and reproduce new observational constraints, from the existence of Pb stars at low metallicity to the composition of stardust. However, in the past 10 years or so, not only we have not reached a firm conclusion on the formation of the main neutron source and on the origin of Sr, Y, and Zr; but also, further uncertainties have appeared, related to stellar rotation and mixing as well as neutron-capture cross sections and beta-decay rates. At the same time, we are confronted by a growing set of observational constraints that are not matched by the current models, from low Pb abundances in post-AGB stars to high Eu abundance in C-rich halo stars. I will summarise the challenges we are facing, the current efforts to discover and exploit possible ways forwards, and some first successes.