MSE study of old metal-poor stars

Aruna Goswami, IIA Bangalore, Bangalore 560034, India

Stars from the second generation (population II stars) inherit the chemical imprint of the first generation. These stars enrich the interstellar medium with the products of their nucleosynthesis during the late stages of their evolution; massive stars as supernova and low-mass stars as AGB stars. Given their long lifetimes (> 10 Gyr) it is expected that the second-generation low-mass stars first formed still shine in the present day universe. Due to the relative paucity of the products of stellar nucleosynthesis in their atmospheres compared to the reference star (Sun) these objects are called metal-poor stars with 'Fe' as a proxy for metallicity. The detailed elemental abundances of these stars can help to reconstruct the physical and chemical processes of early star and galaxy formation and thus improve our understanding of the early universe. However, use of metal-poor stars for such investigation remains limited primarily due to the lack of accurate abundance estimates from old metal-poor stars in different parts of the Galaxy. Significant progress can be expected from high resolution spectroscopic survey with MSE in extending the sample of metal-poor stars covering different classes of metal-poor stars. This will lead to a comprehensive catalogue of metal-poor stars including objects from MSE survey as well as from other on-going surveys such as Skymaper, LAMOST etc. In particular, detailed chemical compositions of these objects will allow us to address specific questions, such as, a) the relevant nucleosynthesis processes and sites of chemical element production, b) the nature of the first stars and their initial mass function, c) early star formation and galaxy formation processes, d) nucleosynthesis and chemical yields of the first supernovae, e) the chemical and dynamical history of the Milky Way, f) a lower limit to the age of the Universe.

Extended MSE (EMES) with higher (R$\geq$ 90000) spectral resolution

While some of the above studies are possible to achieve from analysis of spectra at R $\sim$ 20,000, many fundamental questions need accurate measurements at isotopic levels requiring higher spectral resolution. Two examples are outlined below.

The origin of heavy elements

Isotopes of elements are produced through specific nuclear reactions. Thus any neuton-capture element with multiple isotopes that are produced in different amounts by the s- and r-processes can be used to assess the relative s- and r-process contributions to the stellar composition. As the isotopic abundances for these elements are more fundamental indicators of n-capture nucleosynthesis, they can be directly compared to r-process and s-process predictions without the smearing effect of multiple isotopes. To reconstruct the origin and evolutionary history of neutron-rich elements in the Galaxy it is thus important to extend our study to the isotopic level. The observed abundances of heavy elements are very low at [Fe/H] < -3.5; it is believed that r- and s-process had little contributions to stars formed in the very early Galaxy. However, Ba snd Sr are detected in almost all stars with [Fe/H] < -3 studied so far, although the abundance estimates are quite low, ([Sr,Ba/Fe] ~ -1.5). Accurate measurements of these abundances in an extended sample that will be detected from MSE survey will provide new constaints on the origins of heavy elements in the Galaxy.

The onset of AGB stars contribution to the Galactic chemical enrichment

EMSE will also enable us to address a long standing question on the time at which the first low- and intermediate-mass stars had reached the AGB phase and began to contribute to the Galactic chemical enrichment with the products of nucleosynthesis. The knowledge of the epoch at which the AGB stars had begun to enrich the Galactic halo can help us to delineate the contribution of elements produced by low- and intermediate-mass stars from the contribution of elements produced by massive stars. Estimates of the Mg isotopic ratios, i.e., ^{25}Mg/^{24}Mg, and ^{26}Mg/^{24}Mg with respect to metallicity are particularly important in this regard because they provide clues to the nucleosynthesis history of the star, i.e., whether its isotopic pattern arises from pre-supernovae evolution of massive stars, or other processes such as the contribution from intermediate-mass AGB stars. High spectral resolution with high S/N observations of an extended sample will help constrain the estimates of appearance of AGB stars in the Galaxy and will be useful to better constrain the formation timescale of the Galactic halo.