The Gaia-ESO Survey: Sodium and aluminium abundances in giants and dwarfs Implications for stellar and Galactic chemical evolution

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Abstract

Context. Stellar evolution models predict that internal mixing should cause some sodium overabundance at the surface of red giants more massive than ~1.5-2.0 M. The surface aluminium abundance should not be affected. Nevertheless, observational results disagree about the presence and.or the degree of Na and Al overabundances. In addition, Galactic chemical evolution models adopting different stellar yields lead to very different predictions for the behavior of [Na.Fe] and [Al.Fe] versus [Fe.H]. Overall, the observed trends of these abundances with metallicity are not well reproduced. Aims. We readdress both issues, using new Na and Al abundances determined within the Gaia-ESO Survey. Our aim is to obtain better observational constraints on the behavior of these elements using two samples: i) more than 600 dwarfs of the solar neighborhood and of open clusters and ii) low- and intermediate-mass clump giants in six open clusters. Methods. Abundances were determined using high-resolution UVES spectra. The individual Na abundances were corrected for nonlocal thermodynamic equilibrium effects. For the Al abundances, the order of magnitude of the corrections was estimated for a few representative cases. For giants, the abundance trends with stellar mass are compared to stellar evolution models. For dwarfs, the abundance trends with metallicity and age are compared to detailed chemical evolution models. Results. Abundances of Na in stars with mass below ~2.0 M, and of Al in stars below ~3.0 M, seem to be unaffected by internal mixing processes. For more massive stars, the Na overabundance increases with stellar mass. This trend agrees well with predictions of stellar evolutionary models. For Al, our only cluster with giants more massive than 3.0 M, NGC 6705, is Al enriched. However, this might be related to the environment where the cluster was formed. Chemical evolution models that well fit the observed [Na.Fe] vs. [Fe.H] trend in solar neighborhood dwarfs cannot simultaneously explain the run of [Al.Fe] with [Fe.H], and vice versa. The comparison with stellar ages is hampered by severe uncertainties. Indeed, reliable age estimates are available for only a half of the stars of the sample. We conclude that Al is underproduced by the models, except for stellar ages younger than about 7 Gyr. In addition, some significant source of late Na production seems to be missing in the models. Either current Na and Al yields are affected by large uncertainties, and.or some important Galactic source(s) of these elements has as yet not been taken into account.

Keywords

Galaxy abundances, Galaxy evolution, Stars abundances, Stars evolution, Stars late-type.