Astronomy Reports 1997 vol.41 N4, pages 530-536

Statistical equilibrium of Sr II in the atmospheres of F and G stars

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Abstract

The statistical equilibrium of Sr II in the atmospheres of stars with T eff = 5500-6500 K, logg = 1.0-4.5, and [M/H] from 0 to -3 has been analyzed for the first time. For Sr II, the pumping of excited states by chains of radiative bound-bound (b-b) transitions starting from the ground level and the subsequent photoionization from these states underlie the mechanism of departures from LTE. As a result, the upper excited levels and the Sr III continuum are overpopulated relative to the equilibrium state, the population of the ground 5s level is essentially constant, and the 5p level is depopulated when the b-b transitions are strong (in stars with [M/H] = 0 and -1) and is overpopulated when the b-b transitions from it are unable to remove the pumping produced by the resonance 5s-5p transition (stars with [M/H] = -2 and -3). As a consequence, the subordinate lines that arise during the transitions from the 5p level weaken compared to the LTE case over the entire range of the parameters, while the resonance lines strengthen for [M/H] = 0 and -1 and weakened for [M/H] = -2 and -3. In stars with normal heavy-element abundances, the departures from LTE for all Sr II lines except for the infrared triplet in the 4d-5p transition (λ10400 Å) are small: the non-LTE corrections to the strontium abundance do not exceed 0.05 dex. In metal-deficient stars, the departures from LTE increase with decreasing [M/H], with rising T eff, and with decreasing logg. For the resonance lines, the correction reverses its sign and becomes positive for [M/H] ≤ -2; its value may reach 0.4 dex for main-sequence stars and 0.8-1.2 dex for supergiants. This may be the key to explaining the observed deficiency of s-process elements relative to α-process elements in stars of the Galactic halo.