"Electron screening puzzle" solved

February 26 2016

The energy production in stars utlimately depends on certain nuclear reactions at energies close to the so-called Gamow-peak that affect strongly the chemical composition of stars and the surrounding planetary systems. These reactions appeared also in the early stages of the universe and are connected to the primordial nucleosynthesis of light elements and, in turn, with the chemical composition of distant astronomical objects.

It is therefore of paramount importance to know accurately the nuclear reaction rates and the cross-sections at this somewhat low energy regime (with respect to typical nuclear energies).

The corresponding data measured in underground laboratories and in nuclear accelerators facilities worldwide show a remarkable problem, namely the bare nuclear cross-sections are somewhat systematically higher than the theoretical predictions. A partial 'atomic physics' solution of the problem comes with the realization that the presence of electrons in laboratory materials and in stellar plasma enhances the cross-section systematically by screening the nuclei. However, available atomic physics models cannot account for all the discrepancies seen in experiments and the concept of 'electron screening puzzle' has been around for 20 years.

Now, the italian nuclear physicist C.Spitaleri (Catania, INFN) and the brazilian-american C.Bertulani (A&M Texas University) realized that these discrepancies are stronger when the reactions involve certain nuclear species, such as Li isotopes or 7Be, for which it is well-known

that clusterization occurs. This particular phenomenon appears in some nuclei, the constituents of which take up a clusterized configuration, i.e. they are somewhat like molecular bound states of two smaller lumps of nucleons.

This is energetically favoured with respect to a unique drop containing all the nucleons, due to an interplay between the nucleon-nucleon interaction and the Pauli exclusion principle.

The duo joined forces with other two italian nuclear theorists, L.Fortunato and A.Vitturi (University of Padova) who showed with a simple model that reactions involving clusterized nuclei have a lower potential energy barrier and therefore the Gamow tunnelling factor is enahnced. This explains the anomalous value of the "screening potential" and ultimately shows that is not due to specific properties of those atoms or to their electrons, but to the minute details of their nuclear structure.

More information: C. Spitaleri et al. The electron screening puzzle and nuclear clustering, *Physics Letters B* (2016). DOI: 10.1016/j.physletb.2016.02.019

Provided by University of Padova