Theoretical study of the spectra of nine- and ten-times ionized xenon in the extreme ultraviolet region

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A new set of oscillator strengths and transition probabilities has been obtained for a large amount (~ 650) of radiative transitions of nine-times and ten-times ionized xenon, Xe X and Xe XI, in the extreme ultraviolet region from 102 to 164 Å. They have been deduced by two different theoretical approaches, i.e. the pseudo-relativistic Hartree-Fock (HFR) and the fully relativistic multiconfiguration Dirac-Hartree-Fock (MCDHF) methods, which allowed us to estimate the precision of the final results. The eigenvector compositions were also determined for the first time for all the experimentally known energy levels in Xe X and Xe XI.

Xenon ions in nuclear fusion reactors

In laboratory plasma physics, the radiative properties of noble gas ions present a particular interest since they can be injected into nuclear fusion installations, in the form of solidified pellets, for both fuel introduction and plasma diagnostics [1-3]. As an example, if xenon was inserted into ITER, it could be pumped out without leaving residuals on plasma-facing material, and thus would not be recycled in subsequent discharges. Moreover, the xenon atoms would strip to helium-like ions at the highest plasma temperatures. Consequently, the identification of emission lines and the knowledge of spectroscopic parameters from all ionization stages of xenon will greatly aid modelling of the plasma and facilitate the analysis of the spectra used for the estimation of physical conditions inside the fusion reactors such as densities and temperatures.

Atomic structure and radiative parameter calculations

In the present work, we report the theoretical calculations of electronic structure, transition probabilities and oscillator strengths in Xe X and Xe XI, for which no reliable data has been published so far. These ions are a bit more complicated to model than lower ionization stages of xenon due to the fact that, in addition to configurations of the type $4d^k$ and $4d^{k-1}nl$, some low-lying energy levels have been identified as belonging to the core-excited $4p^5 4d^{k+1}$ configurations (k = 8,9). It is therefore obvious that a core-polarization model potential, like the one used in the HFR+CPOL approach [4], is not sufficient to take such core-valence interactions into account which can only be considered by the explicit inclusion of core-excited configurations in the multiconfiguration expansions. In view of the complete lack of experimental radiative parameters available for Xe X and Xe XI, the accuracy of the data obtained in our work has been assessed by comparing two independent theoretical approaches, i.e. the pseudo-relativistic Hartree-Fock (HFR) [5] and the fully relativistic multiconfiguration Dirac-Hartree-Fock (MCDHF) methods [6], both of them including explicitly the most important intravalence and core-valence electron correlations.

Transition probabilities and oscillator strengths

Using the two different theoretical approaches mentioned above, it has been possible to obtain, for the first time, a set of reliable radiative parameters, i.e. oscillator strengths and transition probabilities, for about 650 Xe X and Xe XI spectral lines appearing in the extreme ultraviolet region. These new results, for which an overall agreement within 20 – 30% was found between both methods for the strongest transitions, complete those we recently published for Xe V – Xe IX ions and are expected to be useful for applications in other scientific areas, such as laboratory plasma physics, where xenon ions are supposed to present a particular interest.

References

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