

Polarizabilities of Actinides and Lanthanides

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Polarizability of single atoms has been a subject of investigation for a long period of time. It determines interaction of atom with light which is used in optical lattice trapping and optical lattice based atomic clocks¹, van der Waals forces between atoms and atom-walls interaction. Experimental measurements and theoretical calculations of polarizability for few-electron elements reach as high as one percent discrepancy. Although for more complicated many valence electron systems there's almost no experimental data nor theoretical predictions due to complexity of such a calculations.

We focus on polarizability calculations for ground and few excited states of lanthanides and actinides. These elements are of the great experimental interest for ultraprecise atomic clocks [1,2], searches for variation of fundamental constants and parity non-conservation [3], application in study of quantum gasses [4,5]. Calculations for atoms with opened f-shell are very complicated and usually have poor accuracy. There is no published data for most of actinides and lanthanides and the accuracy of unpublished results [6] is not determined. We calculate scalar polarizabilities for ground and first few excited states as well as tensor polarizabilities of ground states of opened f-shell elements.

The main consequence of our result is that scalar polarizabilities of different components of the same multiplet does not depend on values of their total angular momentum. This statement holds if electron shell occupation numbers don't differ much. It means that method works better for low lying levels, where the density of states is low enough as well as configuration mixing. Another requirement is absence of close levels of opposite parity that contribute to polarizability of one of the states of multiplet. This means that energy intervals between different components of the same configuration should be smaller than energy intervals between configuration and levels of opposite parity that contributes to its polarizability.

References

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