§12. Theoretical Calculations for Spectra of Xe^{10+} Ions

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Extreme-ultraviolet light sources from compact plasmas are now intensively studied for the next generation of lithography. The emission near 13nm is attributed to transitions in Xe^{10+}.

EUV spectra from Xenon ions in LHD have been measured by puffing Xe gas into plasma with a high resolution spectroscopy. In order to identify the observed lines we have calculated the theoretical data with three different atomic codes, MCDF (Multiconfiguration Dirac-Fock) code by Y.Ki. Kim[1], Cowan (Hartree-Fock) code in relativistic mode[2] and the Hullac code[3].

The ground state configuration of Xe^{10+} is $4p^64d^8$. We studied lines emitted from transitions $4d^8$ - $4d^75p$. For these transitions there are more than 400 lines. Since it is difficult to compare so many lines, we compare the spectra convoluted with a Gaussian profile assuming the integrated line intensity is equal to theoretical value gAr (s-1) where g is a statistical weight of the upper level i, and Ar is the transition probability from the upper level i to the lower level j. In Fig.1 the theoretical convoluted spectra are compared. For many electron system like Xe^{10+} ions, configuration interaction by electron correlation is important. For MCDF code only one configuration is included for upper state ($4d^75p$) and lower state ($4p^64d^8$) (solid line). For the Hullac code we calculated two cases; i) only one configuration like the MCDF code (dotted line) and ii) several configurations ($4p^64d^8$, $4p^64d^74f$, $4p^64d^75s$, $4p^64d^75p$, $4p^64d^75d$, $4p^64d^75f$, $4p^54d^9$) (painted). In Fig.2, the results from the Cowan code with the configurations $4p^64d^8$ and $4p^44d^{10}$ for the lower state and $4p^64d^75p$, $4p^64d^74f$, $4p^54d^9$ for the upper states are shown by solid line together with results by the Hullac code with multiconfigurations (painted).

The convoluted spectra from MCDF and Hullac codes agree well when only one configuration is included. Including more configurations, the spectra by Hullac code change significantly. However the convoluted spectra by Cowan's code with several configurations do not agree with Hullac code result. The results by Cowan's code are rather similar to those with one configuration by MCDF and Hullac codes as hown in Fig.2.

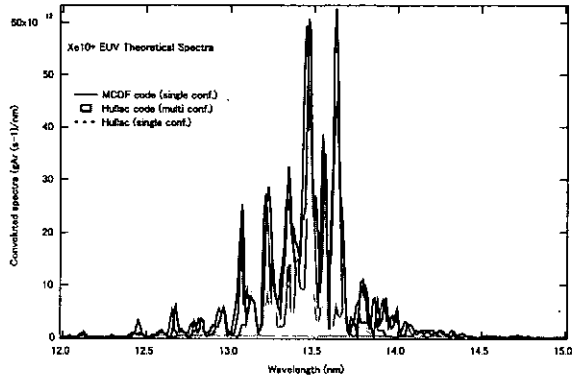

Fig.1 Comparison of the theoretical spectra by Hullac and MCDF code

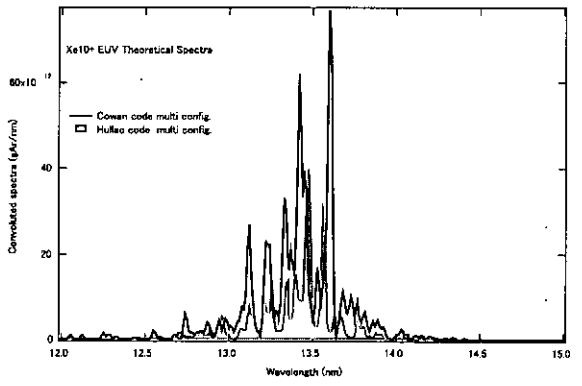

Fig.2.Comparison of the theoretical spectra by Hullac and Cowan code with multi configurations.

We can make a benchmark test of computer codes using the observed spectral lines.

[1]Y.Ki. Kim and M.E. Rudd, Phys.Rev. A (1994)
[2] R.D. Cowan, The Theory of Atomic Structure and Spectra, Univ. of California Press, Berkeley (1981)
[3] A. Bar-Shalom, M. Klapisch and J. Org, Phys. Rev. A38, 1773 (1988)