## §14. Comparison of Calculated and Measured Gain of X-ray Lasers

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Recently, importance of accurate atomic kinetics model is realized to develop efficient, short wavelength x-ray lasers. Moreover, design of another new scheme could be possible using good atomic data. We have mainly studied theoretical and experimental methods to develop atomic model of electron collisional excited x-ray lasers using Ni-like ions.

Simplified level diagram of typical Ni-like soft x-ray laser is shown in Fig.1. In this scheme, considerable improvement of gain using small pump energy is reported using pre-pulse technique. Although qualitative agreement of calculated and measured z-dependence of gain and its temporal and spatial profile has been demonstrated, and production of large population of Ni-like ion and efficient excitation to the upper laser level are expected using this technique[1], quantitative agreement of population, ion abundance and optimization of x-ray gain has not yet been obtained.

As shown in Fig.1, the x-ray gain is obtained in $3d^9 4d(3/2, 3/2)$ J=0 to $3d^9 4p(5/2, 3/2)$ J=1 and $3d^9 4p(3/2, 1/2)$ J=1 transitions. This is because the rate of electron collisional excitation from the ground state to $3d^9 4d(3/2, 3/2)$ J=0 is excessively greater than those for other states. Therefore, determination of the excitation rate from accurate atomic structure is important. The calculation can be performed using MCDF (Multi-Configuration Dirac Fock) codes[2], but for the upper level it has significant difficulty due to relativistic effects and strong electron correlation. Considering appropriate n-expansion and substitution in MCDF method, it is found that the energies of lasing lines agreed with the measured value within 1%. Calculated wavefunctions are useful for successive calculation of collisional rates using DW(Distorted Wave) approximation method.

Another difficulty in development of CRM arises from complexity of level structure. Each lower lying levels are accompanied by double or inner shell excited states. Kinetics of these levels changes ion abundance due to excitation autoionization or dielectronic recomibination, depending on density and temperature[3].

On the other hand, ions which have half filled subshell have too complex structure which can not be fully included in CRM. We have developed a simplified model which includes Ar-like($3p^6$) to Pd-like($4d^{10}$) ions with *n*-averaged levels above n=5, and *nl*-averaged levels for n=4. Energies and collisional and radiative rates for averaged levels are calculated using screened hydrogenic approximation. This model turned out to be useful because it could reproduce ionization potential of highly charged ions within few % of experimental value[4]. Large abundance of Ni-like ion for wide range of temperature density is also reproduced.

References

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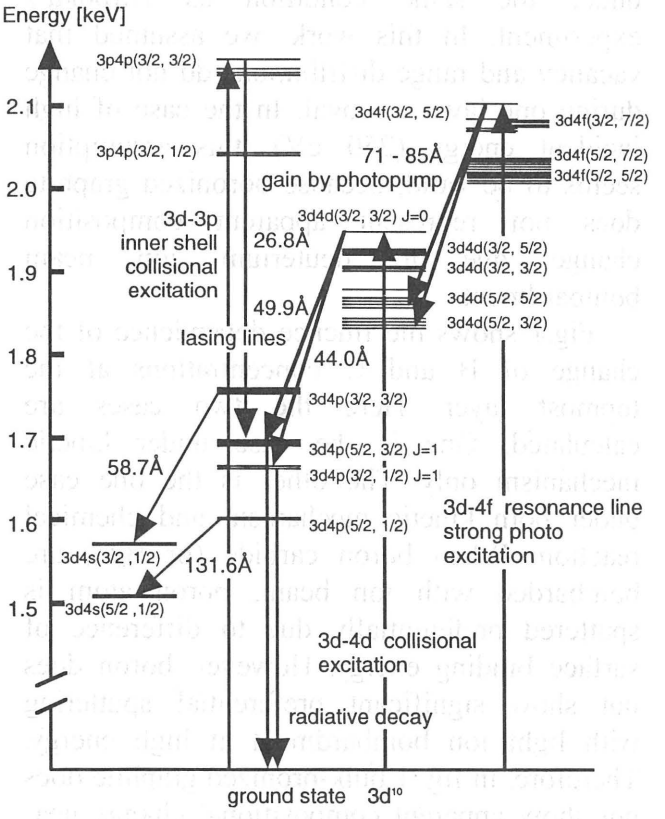


Fig.1 Level diagram of Ni-like Ta