Quantum coherence and inner-shell x-ray lasing in XFEL generated NLTE hot and dense plasmas

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High bright x-ray free electron laser (XFEL) with photon energy of hundreds to thousands eV can directly ionize the inner shell electrons of atoms, inducing sequential ionization processes such as Auger decay, electron impact excitation, ionization, and electron attachment. Dozens of electrons can be ionized from complex atoms within a few femtoseconds to tens of femtoseconds, resulting in a non-equilibrium plasma containing dozens of ionization stage of ions with exotic electronic configurations and hundreds of eV temperature free electrons [1]. Based on the classical rate equation and the quantum density matrix evolution equation, we have studied the ionization kinetics process and dynamics of gas/solid target [2] and possible atomic x-ray lasing [3,4] on the basis of detailed level accounting model. Based on finite difference and Monte Carlo numerical methods, the numerical calculation program can simulate the evolution process of rate equation containing tens of millions of atomic energy levels, as well as the time-dependent evolution process of density matrix containing thousands of quantum states. The results will demonstrate the precise atomic kinetics and the impact of quantum effects on ionic stage and energy level population evolutions.

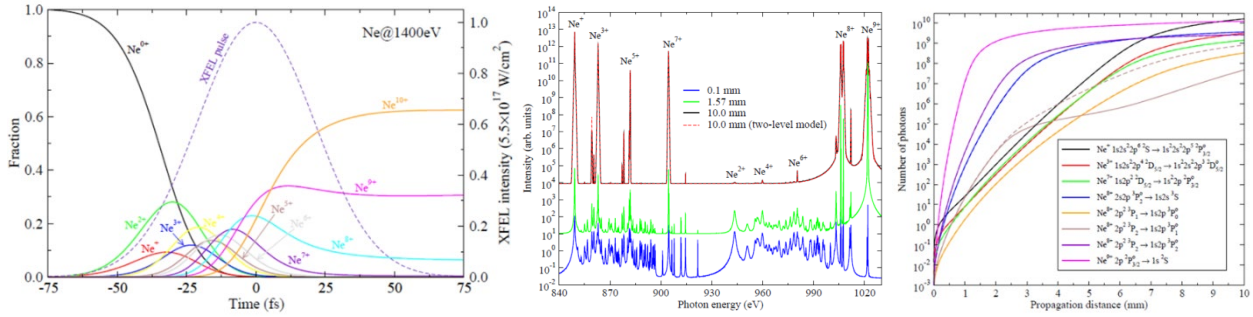

Figure 1. XFEL photoionization pumped Ne atom inner shell lasing amplification. (left) Evolution of different charged Ne ions populations with time, (middle) spectral distribution of emitted x-rays propagating at different distances in a medium, and (right) gain curves of some selected transitions.

References

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