§27. Development of Internet Vertical Atomic and Molecular Database for Studies of Light Sources and Plasma Processing

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We have witnessed recent fast, significant and remarkable advancement in past decades in areas such as high-tech. industries, medical research, environmental science, atmospheric science, fusion sciences as well as other basic sciences including astrophysics and radiation physics and chemistry, which are fully depend on extensive utilization of atomic and molecular (A&M) data for basic understanding of various phenomena, but also establishing guiding new key principles and basic technologies based on simulations with this accurate and complete A&M data basis.

We held meetings on May 9, June 19, and Oct. 23 2015. We held a joint seminar on Jan. 27 – 29, 2016 to discuss present status and future prospect of A&M data, mainly for multiple-charged ions in the magnetic fusion plasmas and laser-produced plasmas. Furthermore, the principal investigator of the project participated in the EUV source workshop held at Dublin, Ireland, on Nov. 9 – 11 to discuss physics of plasma EUV sources including atomic processes of multiple charged ions from Sn to Bi, and nLTE kinetics workshop (nLTE-9) held at Paris, France, on Nov. 30 – Dec. 4 for the development and validation of the atomic kinetics codes as well as the rates of ionization and excitation by the electron collision and radiation of Fe ions in plasmas.

In the nLTE-9 workshop, the ionization balance, level population and radiative power loss calculated using atomic kinetics codes developed in different institutions are compared each other. It is shown that calculated atomic energy levels and rate coefficients of Fe ions are accurate enough and reproducible between different atomic codes such as GRASP, HULLAC, and FAC. It is shown that results for Fe plasmas from different atomic kinetics codes agree well each other if the same set of atomic energy levels are included in the calculation.

On the other hand, the calculation for heavier ions such as W has more uncertainties due to difficulties of calculating atomic structure of complex ions and difficulties of calculating dielectronic recombination rates taking a large number of possible channels. We investigated the ionization and recombination rates of W plasmas, which are interested in magnetic fusion plasmas [1]. The maximal uncertainty of calculated dielectronic recombination rate of W estimated to be approximately factor of 2, depending on the method of calculation and corresponding accuracy of the atomic energy levels. Nevertheless, the ionization and recombination rates for a wide range of charge states of W ions are found to be useful for modeling transport in magnetic fusion plasmas, and the development of database for these rates should be considered.

The importance of the database of atomic data and atomic codes is also realized in the study of the EUV source. The database will enable one to develop EUV source over wide range of wavelength using a variety of atomic transitions. Unresolved Transition Array (UTA) from Sn ions is shown to be useful for the EUV source at λ=13.5nm., because a large number of atomic transitions overlap at the same wavelength region resulting in the EUV emission can be obtained with high efficiency. The 4d-4f UTA is scalable to shorter wavelength using heavier ions, however, line sources may also be useful because the emission is more concentrated into the target wavelength. Radiative loss from hot plasma may have considerable effect to the achievable temperature and ionization charge of the plasma. To analyze their effect a coupled analysis of atomic processes and radiation hydrodynamics is necessary. Using the database, the performance of such sources can be estimated by the simulation.

As a collaboration project, we discuss the possibility to improve productivity of the research, especially with respect to the planning and organization of seminars and workshops. We see the importance of the collaboration between data producers and data users, that is, basic scientists who are interested in atomic physics and atomic collisions, and scientists and engineers from application fields. To make the seminar more useful, appropriate speakers should be nominated, and feedbacks from participants should be collected and used for the planning of the next seminar. Information of each speakers and their presentation should be distributed to the participants through the web site. We have investigated available internet services to see social network services (SNS) may be more suited for communication between collaborators than conventional e-mails. Using SNS, discussions for a particular topic are displayed using threads, which is easier to recognize. The range of distribution of the message can be controlled easily. On the other hand, there are several different SNSs and the most useful one for the collaboration project should be chosen. For that, we may need to understand the concept of each SNS through experiences of using SNS, also to avoid security and privacy problems.

[1] A. Sasaki et al., J. Phys. B46, 175701 (2013).