

## §8. Atomic Processes in Non-Maxwellian Plasmas

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In the workshop of this program, the present status of researches of atomic processes in non-Maxwellian plasmas, especially in directionally anisotropic plasmas, have been reviewed and future prospects of this research field were assessed. In this context, Fujimoto reported on the recent meeting of The Japan-US Workshop on Plasma Polarization Spectroscopy (PPS) and The International Seminar on Plasma Polarization Spectroscopy, held during January 26-28 in Kyoto. It was attended by 15 workers from the overseas countries and 17 domestic workers. The topics covered the PPS studies on tokamak plasmas, a vacuum spark, discharge plasmas and a laser-produced plasma. An MSE experiment on CHS was reported. Polarized laser-induced fluorescence spectroscopy was applied to a discharge plasma. Polarization dependent emission line profiles were introduced which stem from coherent coupling of static fields and dynamic fields. In industrial plasmas for, *e.g.*, plasma etching, characteristics of the anisotropic velocity distribution of electrons and ions are very important for their performance, but there is no experimental means to detect the velocity anisotropy. Thus they await a PPS study. Atomic physics is very important in interpreting the experimental results in PPS. Several experiments of emission line polarization from EBIT were reported along with interpretations of their results. Creation or destruction of alignment in an atomic ensemble by electron collisions was discussed from the theoretical and experimental viewpoints.

In the present workshop, recent results of PPS measurement on the WT-3 tokamak were reported. From the polarization degree and the intensity of berylliumlike oxygen triplet lines, an electron velocity distribution is suggested in which the poloidal temperature is one third the toroidal temperature.

Hori reported on the temperature anisotropy of the inductively coupled plasma. For plasmas with temperature of 2.5 eV and density lower than  $10^{18} \text{ cm}^{-3}$  the

perpendicular temperature is found higher than the longitudinal temperature. The presence of the velocity anisotropy is consistent with the thermalization rate of electrons by coulomb collisions.

JAERI has a project to develop a  $T^3$  laser and apply it to develop an x-ray laser. Three reports were presented. Sasaki reported the recent progress in their development of a simulation program of multiply ionized ions in a rapidly changing dense plasma. They incorporated many excited levels of nickellike ions and ions in several nearby ionization stages. The excited-level populations and the population inversion calculated by the new code were appreciably different from those by the code without these levels. Nagashima reported the simulation results of the optical field ionization (OFI) of atoms, molecules and clusters. The characteristics of the velocity distribution of electrons and that of the ions after OFI changes continuously from atoms to solids: the initial anisotropy is very strong in the case of ionization of atoms and it decreases when we go along molecules, clusters and to solids. The directional anisotropy disappears much faster than the time when the speed distribution relaxes to Maxwellian. Sagisaka reported the simulation results of the recombining phase of the OFI plasma by taking hydrogenlike ions as an example. Depending on the condition, the population inversion for the Lyman line developed.

Fujimoto discussed the radiative recombination of electrons having a unidirectional velocity distribution, say in the  $z$ -direction. When an electron recombines with an ion to produce the  $1s$  ground state ion, the recombination continuum it emits is polarized in the  $z$ -direction, or it is the  $\pi$ -light. We expect that almost every characteristic of the low energy continuum electrons and the associated radiation characteristics should continue smoothly across the ionization limit down to the high-lying excited levels. A natural consequence is that the resonance-series lines should be polarized in the same direction. This means that, in this directional plasma, the population is concentrated on the  $m_l = 0$  magnetic sublevels. Imaida reported his Monte Carlo simulation results of the electron collisions in a classical atom in a highly excited state. It was concluded that elastic collisions do not concentrate the atomic populations to the  $m_l = 0$  sublevels, and that two electrons traveling in the same direction cannot make a three-body recombination.

Kagawa reported sequence of radiative transitions of hollow atoms, and estimated ionic states from the observed spectrum of emission lines of the ions produced by collisions of the ions with a solid surface.