A ROUTE TOWARDS TRANSMUTATION OF MATTER;

Basic concepts of photo-induced cooperative phenomena.*

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Understanding and controlling non-equilibrium electronic phenomena is an outstanding challenge in materials science and engineering. The photo-induced cooperative phenomena, particularly photo-induced transformations posses a high potential for “modern alchemy”, e.g. changing structures and properties of materials (transmutation) using physical methods and tools. Here we will briefly introduce/remind basic concepts (and models) which were at the beginning of quickly growing interest in cooperative phenomena, photo-induced phase transitions (PIPT).

First of all, intuitive picture to consider the crossover of the excited and the ground electronic states and correlating static and dynamic phase transitions through the notion of condensed elementary excitations has been proved very useful and the concept of condensation of self-localized excitons has been developed *(**Toyozawa, Nasu**)*. Cooperative nature of the phenomena has stressed a role of lattice dynamics e.g. extended perturbation of a lattice in stabilization of excited sites, deformation versus excitation energies (***Toyozawa, Nasu, Hanamura, Nagaosa***). Early studies have been summarized during the ***19-th Taniguchi Symposium 1996***, which may be considered as the beginning of the series of PIPT conferences. Progress in understanding of the PIPT phenomena has been to a large extend, due to pioneering and stimulating experimental works on polidiacatylene and TTF-CA, (***Koshihara)*** and later experiments on TTF-CA as a model system (***Cailleau, Koshihara, Okamoto***).

From the first (PIPT1) conference, the cooperative nature of the phenomena and the concepts of hidden multi-stability (ground state versus false ground state) and the proliferation mechanism of lattice relaxed optically excited states giving rise to a formation of new lattice structure and electronic order, have been stressed. This conceptual nature of PIPT has been schematically illustrated by well known diagram (***Nasu***). The challenge was therefore how to transform this intuitively accepted picture into microscopic model(s) ?

Simplest models were developed for linear systems with diabatic (adiabatic) on-site two states potentials which are coupled elastically with other sites. The elastic field of a system is assumed to be responsible for proliferation mechanism of on-site perturbation. Extended versions were developed for delocalized (itinerant) electron systems and extended elastic coordinates (including intra-molecular degrees of freedom), (***Nasu, Yonemitsu***). Some basic problems in physics of phase transitions have also been addressed in the context of PIPT, such as spontaneous translational symmetry breaking (***Nasu***) or non-equilibrium dynamics (***Cailleau***).

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