European Study Conference on Multiphoton Processes

Seillac, France, 14-17 April 1975

After an opening address by Professor J. Yvon, Haut-Commissaire à l'Energie Atomique, who encouraged the attendees to investigate the effect of multiphoton processes on the thermodynamical behaviour of systems of radiation and matter, the conference was mainly devoted to multiphoton absorption. It consisted of fairly long review papers on well defined topics (both experimental and theoretical) followed by ample and sometimes passionate discussions.

Much knowledge has been accumulated since the early days of naive gas breakdown experiments in which the physics was hidden behind a mixture of competing and not all identified phenomena. That was some ten years ago. By that time the first well behaved theories of multiphoton ionization (Keldysh, Bebb and Gold) appeared. Soon afterwards the first experiments were made in which the phenomenon was isolated (Voronov and Delone).

Now, the field of multiphoton processes is no longer restricted to the photoelectric effects as two remarkable talks let it be known in this conference. The first one was by C. Cohen Tannoudji (Collège de France, Paris) in which it was shown how the radio frequency interaction with (dressed) atoms can be reinterpreted in terms of multiphoton phenomena although this interpretation is by no means necessary. The other talk was by B. Cagnac (Ecole Normale Supérieure Paris) on Doppler - free two photon spectroscopy which opens new perspectives in the knowledge of the structure of the atom and of gas kinetic theory. More exotic was a paper by C. Itzykson (Physique Théorique Saclay) on high energy physics.

G. Mainfray reviewed the experimental work made both in Saclay and at the Lebedev Institute in Moscow. The main emphasis was on resonant processes and on coherence effects. Tunable lasers make the former easier to observe and provide accurate measurements of level shifts due to intense fields. The latter were investigated through the variation of the number of modes of the laser output. An increase of the ionization probability with the number of modes is found to be in rough agreement with theoretical predictions. The role of phase locking was clearly evidenced. It is worth while to notice that the experimental techniques now have a high degree of sophistication : the atoms under investigation may be varied in such a way that the number of photons involved can be changed and the intermediate levels carefully chosen to be either in the resonant or the off resonant case.

Other experiments reported deal with microwave ionization (Bayfield, Yale University), molecular intermediate states (Collins, University of Texas at Dallas) and surface effects (Farkas - Budapest). Surface multiple photoelectric effect deviations from the $\varnothing^S$ law under high intensity laser irradiation, and polarization effects were carefully investigated.

In every experimental talk, the same concern arose : how do the data fit the present day existing theories. The answer varies from a reasonable agreement (coherence, polarization) to further puzzles. Obviously, theories do not fit so well a lot of experimental data. The theoretical part of the conference was thus slightly disappointing : a kind of scientific blindman's buff game.

The main point of interest (and controversy) deals with the deviation from the $\varnothing^S$ law where $\varnothing$ is the radiation flux density and is defined by

$$(S^{-1})\,\hbar\omega < \chi_1 < S\,\hbar\omega$$

where χ_1 is the first ionization potential and ω the circular frequency of the laser radiation. Resonance effects have been obviously suspected from the beginning. However one needs a detailed knowledge of the atomic theory: intermediate levels, forbidden transitions, level shift and distortion under the action of a high intensity laser field . . . Unfortunately this knowledge is still far from complete and no theoretical approach looks really satisfactory.

The methods used so far can be classified into two main branches : perturbative and nonperturbative theories. Both were reviewed by Y. Gontier. The former are the most commonly employed. It is expected that the lowest order non-vanishing term is to describe the phenomenon under investigation. This view-point fails for high intensities and resonant cases. Then one has to know the atom wavefunctions and evaluate an infinite series over intermediate states. Green functions are extensively used either directly or just as intermediary (Rapoport, University of Voronej) in a method involving the solution of Schroedinger's equation by standard perturbation theory in the rotating frame for circularly polarized light. Such a calculation takes into account the mixing of levels.

Non perturbative theories, except the tunneling first investigated by Keldysh, are actually pseudo perturbative. Unitary transformations either lead to wrong developments, momentum translation originated by Reiss, or simply to a different formulation : for instance the space translation (Henneberger, Southern Illinois University) gives results which are not essentially different from those by Gontier and Trahin.

One might also have a shift of the continuum (J. Bakos, Budapest). The number S would then increase but the transition probability is smaller. This phenomenon may account for an apparent decrease in the slope of experimental curves in the ln N, ln $\varnothing$ diagram, which is commonly smaller than S.

The effects of polarization (selection rules are different for linear or circulary polarized light) were reviewed by P. Lambropoulos (University of Texas at College station) who was also noted as the most active participant in the discussions.

The discussions were numerous and truly stimulating. Thus the conference organized in long review papers followed by ample discussions was of interest for both the specialist and the layman in the field. With a Gordon flavour it was a good example of what a European Study Conference should be.

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