KFKI-76-45

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BUDAPEST

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Submitted to Physics Letters A.

ISBN 963 371 159 2

ABSTRACT

Increase in the order of non-linearity has been found in the experimental intensity dependence curves of the multiphoton photoeffect of gold induced by intense single, picosecond laser pulses having subpicosecond substructure. The effect may be attributed to the theoretically predicted /4/ simultaneous occurrence of multiphoton photoeffects of different orders arising from the modified tail of the Fermi-distribution.

АННОТАЦИЯ

Изучая кривую зависимости поверхностного многофотонного фотоэффекта Au от интенсивности, вызванного единичными лазерными импульсами с субпикосекундной структурой /$\sim 10^{-13}$ сек/, наблюдалось увеличение порядка нелинейности. Это явление можно объяснить теоретически предсказанным /4/ одновременным возникновением многофотонных фотоэффектов различного порядка вследствие изменения хвоста кривой распределения Ферми.

KIVONAT

Pikoszekundumnál rövidebb /$\sim 10^{-13}$ sec/ szubstrukturával rendelkező különálló lézer-egyimpulzusokkal vizsgálva Au katód felületén a sokfotonos felületi fotoeffektust, a nemlinearitás rendjének növekedését tapasztaltuk. A jelenség fellépésének valószinü oka az, hogy az ultrarövid lézerpulzusok hatására módosult Fermi-tail egyes elektronjai számára lehetőség nyilik egyidejüleg fellépő különböző rendü sokfotonos fotoeffektus utján történő kilépésükre, amint azt a közelmultban elméletileg megjósolták /4/.

The work function "A" of metals is determined in general by the Fermi-Dirac distribution of conduction electrons. On irradiation with common laser beams of intensity I and frequency ν emission of surface multiphoton photoelectric current can be produced as long as the Fermi-Dirac distribution remains unchanged. According to the theory this process is characterized by the $j \propto I^n$ relation with the order of nonlinearity up to several GW/cm^2 intensities with $n = n_o = [A/\ h\nu\ +1]_{integer}$. Above this intensity lower n values than n_o were predicted /6,7,8/.

These predictions have been experimentally verified. /1,2,3,8/

In all of the reported experiments, however, laser pulses of regular smooth time and spectral distributions were used, with durations longer than $\sim 6 \times 10^{-12}$sec. In contrast to these results, higher orders than n_o where also observed /1/ with mode-locking pulse trains under special experimental conditions.

Owing to the possible effects arising from the train properties, the determination of the order of nonlinearity n might be questionable. In order to be able to draw exact conclusion on n, it was necessary to repeat the experiments under the same conditions as in /1/ with electrooptically selected single Nd-glass laser pulses and Au cathode.

Our experimental arrangement was the same as in /1/.

The obtained results show that when selecting single $\sim$6 psec bandwith limited smooth pulses from a pulse train, the theoretically predicted n_o=5 value and its decrease at higher intensities can be observed. On the other hand, when using single pulses having irregular subpicosecond time structure, always $n > n_o$ was obtained, with n=6-9. This suggests that this anomaly really exists, and that it is not caused by the successive sequences of the pulses in the case of trains.

Considering that the Richardson emission also may cause such high n values, the polarisation dependence of the electron current was investigated which in the case of thermionic emission is quite different from that obtained for surface photoeffect. Our recent experimental results prove that this emission is a pure surface photoeffect just as in /3/, but corresponding to higher n values.

The existence of an $n > n_o$ order photoeffect seems to be in contradiction with the former theoretical expectations.

The interesting theoretical work /4/ published recently, however, may give a possible explanation as follows. Modifications of the Fermi-Dirac distribution cannot be always ignored, owing to the ultrafast possible /heat/ energy exchange between photons and conduction electrons only. As a result, the original Fermi-tail will be lengthened, permitting some electrons to escape via multiphoton photoeffect, switching on each of the $n \leq n_o$ order photoeffects. The resultant n will be higher than n_o depending on both the intensity and the duration of the laser pulses.

It should be noted, that the laser pulses with wich this effect was observed have an overall length of 10 - 50 psec, with time fluctuations of 10^{-13} sec /5/.

The measurements performed by relatively long single 30 psec regular YAG laser pulses /2,3/ gave the theoretical n_o value.

Therefore, the relatively long duration itself cannot explain the occurrence of the effect. The effect may be caused by either the subpicosecond structure itself, or this substructure superimposed on a long duration background of 10 - 50 psec. Not being able to assign a definite intensity value to the mentioned irregular pulses, a direct comparison with the theory /4/ will be possible only when the state of art of the measuring technique of the subpicosecond durations will be improved.

Thanks are due to Mr. H. Cséry and Mr. K. Titschka for their technical assistance.

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62.328

Kiadja a Központi Fizikai Kutató Intézet
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Példányszám: 275 Törzsszám: 76-663
Készült a KFKI sokszorosító üzemében
Budapest, 1976. julius hó