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LASER FIELD ASSISTED PHOTOEMISSION USING FEMTOSECOND LASER PULSES *

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Laser field assisted photoemission using femtosecond laser pulses*

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Photoemission from Cu mirror at a laser fluence of 10^{11} W/cm^2, 300 fs, pulse is investigated for various angles of incidence, intensities and polarizations. Electron emission is enhanced by $\sim$20 from s to p polarization and by 4 on changing the angle of incidence from 0 to 73 degree.

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Photoemitters are currently used extensively as electron sources where high current, low emittance electron beams are required, as in short wavelength FEL and high energy colliders[1,2]. For these applications, rugged photocathodes capable of fast, efficient response are needed and hence methods to improve the quantum efficiency without increasing the emittance are important. In this paper we report the enhancement of quantum efficiency using the high electrical fields associated with high power lasers.

The laser used in these experiments is the output of a colliding pulse mode-locked laser at 630 nm, amplified by a nitrogen laser. The 1 μJ pulse in 300 fs is focused to a waist diameter of 50 μm onto a diamond turned Cu mirror cathode to provide a laser intensity of 10^{11} W/cm^2. The anode is mounted parallel to the cathode with a electrode gap of 3 mm, inside a vacuum cell maintained at a pressure of 10^{-9} Torr. The anode is biased to 4 kV and the signal from the cathode is measured after processed through a preamplifier and a shaping amplifier. The electrode assembly can be rotated inside the vacuum so that the angle of incidence on the cathode could be changed. The polarization of the laser beam is changed by rotating the half waveplate in the beam path. The intensity of the laser beam is varied using the half waveplate and a polarizer combination.

Fig. 1 represents the electron yield as a function of the angle of incidence for p-polarized light. The maximum yield is obtained at an angle of incidence of 73 degrees and is four times higher than that at normal incidence due to the combined increase in the absorption and the optical field component normal to the surface. Fig.2 illustrates the polarization dependence of the electron emission at 73 degrees. The ratio of the yields at p and s polarization is > 20 indicating that the emission at this angle is primarily due to the laser field. Comparison of the yields at normal incidence and at 73 degree with s-polarized light indicate that it scales inversely with the square of the area implying a simple two photon photoemission in this arrangement. For Cu, the electric work function is 4.1 eV and hence the photoemission is expected to be a two photon process for the photon energy of the laser. However, for an average intensity of 80 GW/cm^2, the Schottky effect[3] reduces the work function of copper by 1 eV. Since the peak field is much higher, the reduction in the work function is even higher, thereby requiring less than 2 photons to release the electrons. The intensity dependence measurement at 73 degrees indicate a slope of 1.5 on a log-log plot supporting the optical field assisted photoemission. The quantum efficiency at an input intensity of 80 GW/cm^2 is 4×10^{-4}. In conclusion, the increase in the absorption and the optical field normal to the photocathode surface can be used effectively to increase the electron yield of the material. The effect of the electron temperature on the emission needs to be investigated further.

References

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Figure Captions

Fig.1 Photoemitted charge as a function of the angle of incidence for p-polarized laser radiation.

Fig.2 Photoemitted charge as a function of polarization of the linearly polarized radiation. The maximum and minimum signals correspond to p and s-polarized light respectively.

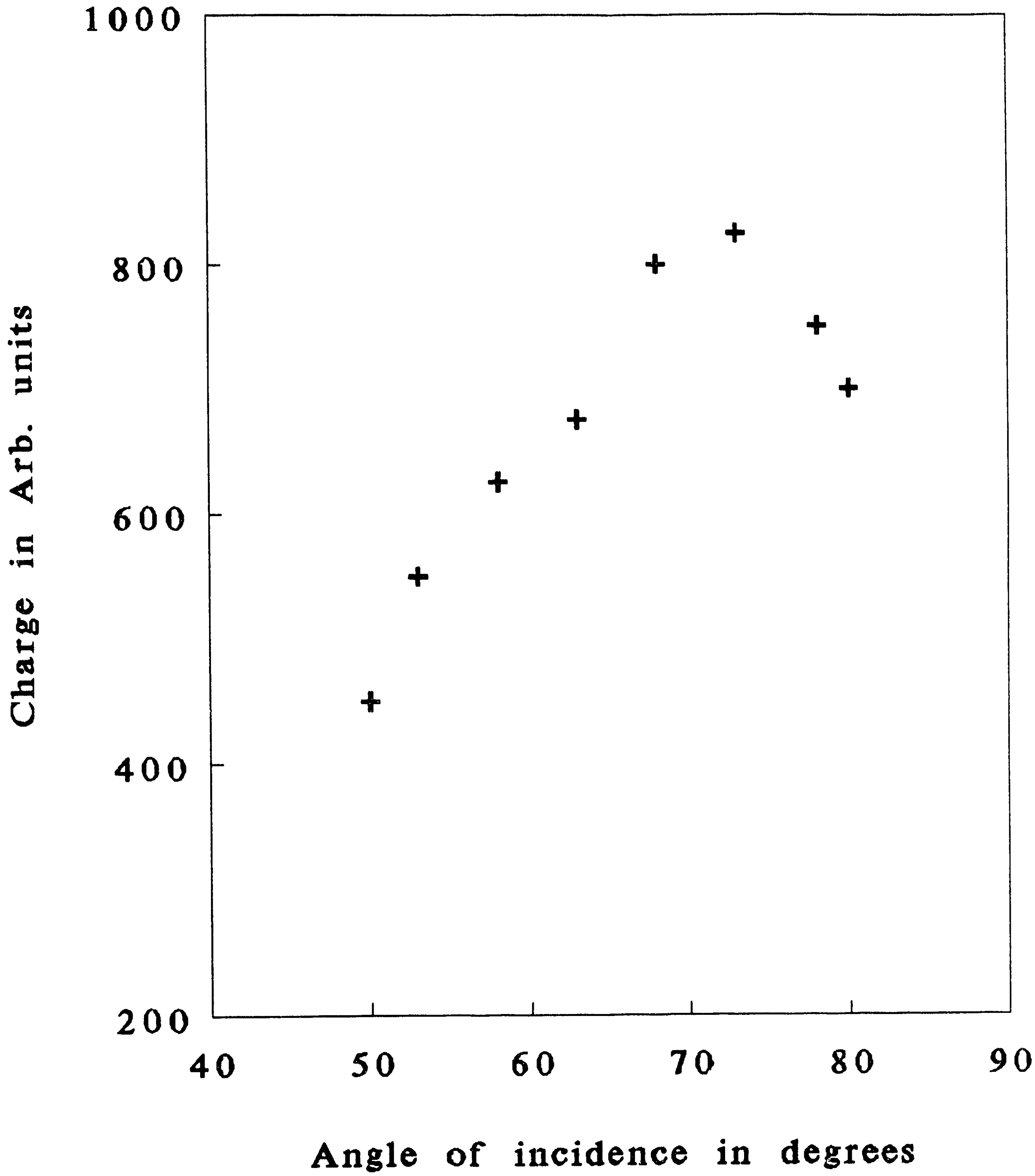
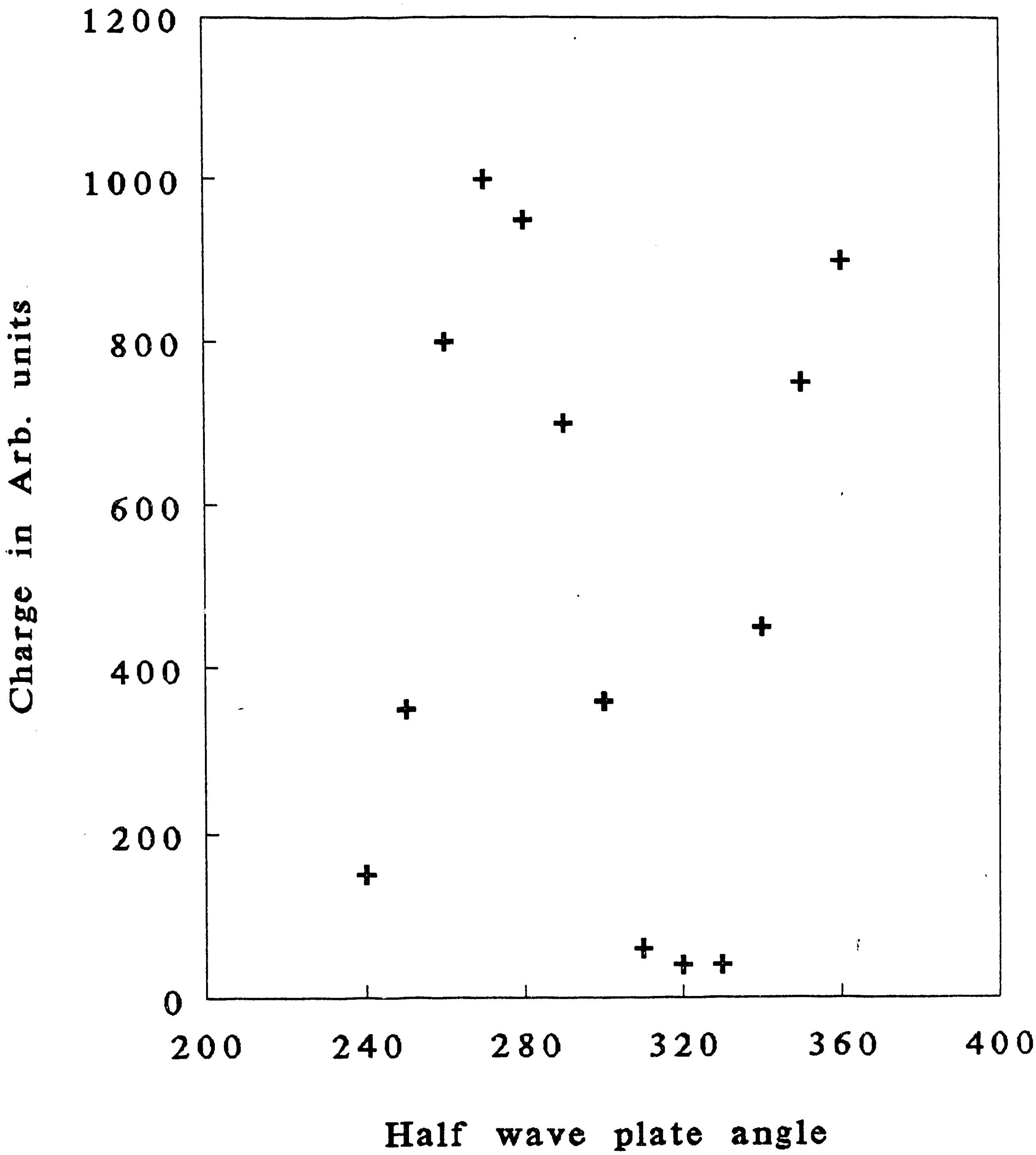

1000
800
600
400
200
Charge in Arb. units
40
50
60
70
80
90
Angle of incidence in degrees

FIGURE 1



1200
1000
800
600
400
200
0
Charge in Arb. units
200
240
280
320
360
400
Half wave plate angle

FIGURE 2

END

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