Contribution of large amplitude electric-field pulse and bursts to particle acceleration in a high-voltage linear plasma discharge

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This paper presents our new findings that electric-field pulse and burst cause intense particle acceleration, although their action and effect are fairly different.

Details of the experimental apparatus, diagnostics (including the measurement of electric field parallel to the magnetic field) were described in our previous papers[1]-[2]. An initial plasma (deuterium) was produced by a titanium washer gun. Hard x ray fluxes and D-D neutron emission (2.45 MeV) were detected by considering temporal coincidence with explosive electric field behaviors.

Fig.1 shows that a large amplitude electric-field pulse and burst break out sequentially at the onset of a high-voltage linear plasma discharge.

Fig.1 Time trace of the electric field (parallel to B) measured at the center of the device

1. Contribution of the Phase I electric- field pulse to particle acceleration

At first, we name the period: t=26.4-27.1 micro.sec as Phase I during which the large amplitude electric-field pulse appeared and the period:t=27.2-27.7 micro.sec as Phase II during which the electric-field burst appeared.

Due to unfavorable electromagnetic disturbance caused by the high-voltage linear plasma discharge, hard x ray and neutron signals were highly contaminated. Hence we calculated cross-correlation functions between the electric field (measured at the center of the device) during Phase I and both hard x ray and neutron emissions. Now we briefly summarize some interesting results obtained by cross-correlation functions between the electric field and both the associated hard x-ray and neutron emissions, although the latter is very weak and temporally spiky.

In the first place, the electric-field pulse(abbreviated as E-field pulse hereafter) in Phase I caused hard x ray emissions parallel to the magnetic field with preferential directivity in the direction toward the anode. This means that the E-field pulse represents a strong double layer and accelerates electrons up to energies sufficient to emit hard x rays with energy higher than 20 keV. The cross-correlation functions between the electric field in Phase I and both the hard x-ray emission perpendicular to the magnetic field and the neutron emission showed the same peaking at time lag tau =0.05 micro.sec, where difference of the time of flight (55 ns) for neutrons and hard x ray photons to reach each detector was taken into account.This time lag is approximately one-fourth the E-field pulse width. Hence the E-field pulse, if it could be interpreted as a strong double layer, did accelerate particles and produced nonthermal energetic electrons and deuterium ions which gave rise to appreciable neutron emission.

2. Contribution of the Phase II electric-field burst to particle acceleration

The electric field burst(abbreviated as E-field burst hereafter)in Phase II produced nonthermal electrons which caused intense hard x ray emissions preferentially in the direction perpendicular to the magnetic field. It also produced nonthermal ions which caused fairly weak neutron emission. Obtained cross-correlation functions between the electric field in Phase II and both hard x ray and neutron emissions show that contribution of the E-field burst to particle acceleration has different character compared with that of the first E-field pulse, but certain common mechanism works to accelerate electrons and ions at specific timing of the E-field burst.

The auto-correlation function of the E-field burst in Phase II showed characteristic profile relevant to particle acceleration, and its details will be reported at the Symposium on Plasma Science.

References

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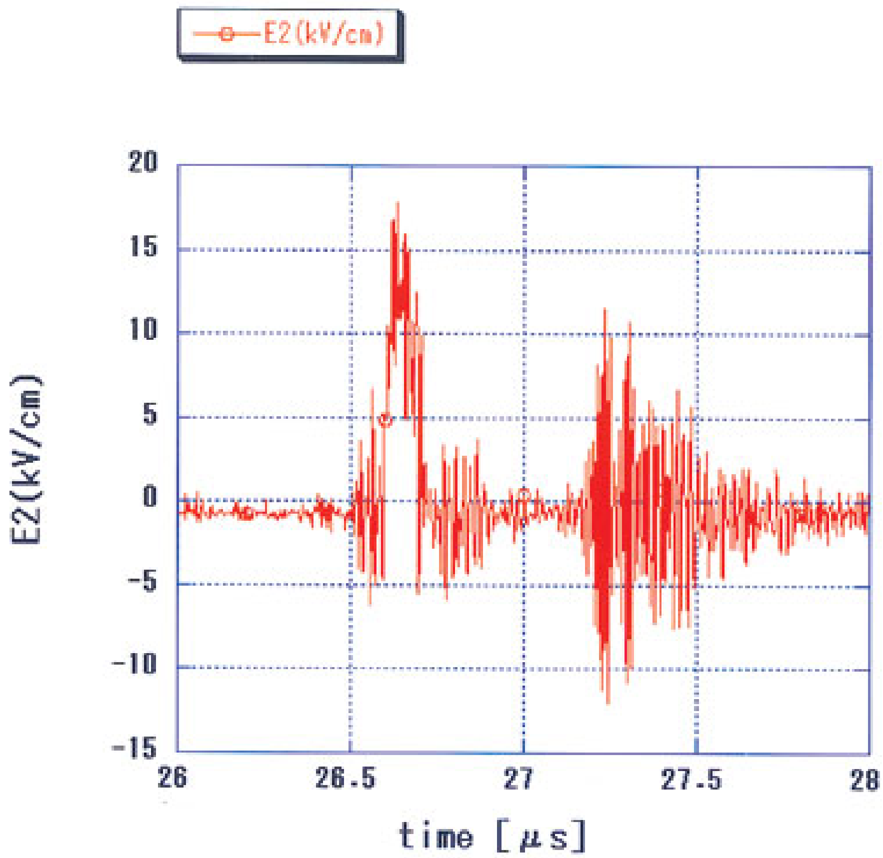
[2] Y.Takeda and H.Inuzuka, Proc.13th International Toki Conference on Plasma Physics and Controlled Fusion(ITC-13) J.Plasma Fusion Res.SERIES,Vol.6(2004),562



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