# Relativistic electrons from the laser plasma in the DEL'FIN device

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Threshold Cerenkov counters have been used to detect and study the energy carried off by electrons from the laser plasma in the DEL'FIN laser device. The threshold energy for the detection of electrons was varied from 200 to 400 keV.

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Research on the emission from a laser plasma is important to the problem of laser-controlled fusion.[1] As the power of the laser devices increases there is an increase in the energy of the radiation emitted from the plasma, and the composition of this radiation changes quantitatively and qualitatively. These changes may result from an increased role of processes that were previously not apparent. One such process is the theoretically predicted production of relativistic electrons.[2]

In this letter we report the observation and study of the emission of relativistic electrons with energies of several hundred keV produced by the laser plasma in the DEL'FIN device, which is described in Ref. 3. Threshold Cerenkov counters were used for the measurements of their insensitivity to all types of radiation from the laser plasma other than electrons.

In the experiments, the radiator of the Cerenkov counter was positioned in the window of the target chamber at a point 30 cm from the target. The window was covered with aluminum foil (a filter), which did not transmit light, soft x rays, or ions. The electrons emitted from the laser plasma passed through the filter, penetrated into the radiator, and caused Cerenkov radiation (or "Vavilov-Cerenkov radiation") in it. This emission was measured by a photomultiplier, whose output signal was fed to an S7-10B high-speed oscilloscope. This oscilloscope was triggered synchronously by a pulse from a coaxial photocell which detected the light flash from the laser plasma. The threshold electron energy $E$ or the cutoff energy of the Cerenkov counter was determined by both the refractive index of the radiator material and the aluminum filter. The energy carried off by the electrons, $I$ (the total energy of the emitted electrons with energies $E_e \geqslant E$), was determined from the height of the signal from the Cerenkov counter. The measurements of the energy carried off by the electrons were accompanied by simultaneous measurements of the yield of x radiation from the laser plasma, carried out with a scintillation counter with an entrance filter of the same thickness as that used for the Cerenkov counter. In some cases the emitted energy measured by the scintillation counter exceeded the energy carried off by the electrons by a factor of $10^4$. In the face of this ratio we cannot rule out the possibility that the polymethyl methacrylate counter was also detecting x radiation by virtue of luminescence. It should be noted, however, that in some experiments, with the same amount of energy carried off by x radiation, no signal was observed from the Cerenkov counter with the polymethyl methacrylate radiator. To improve the reliability of the results we used a water radiator, for which the scintillation yield is 170 times lower[4] than that of polymethyl methacrylate.

In the measurements of the energy carried off by the electrons, the Cerenkov counters could also detect the $\gamma$ radiation resulting from the conversion of photoelectrons and Compton electrons in the radiator with an energy exceeding the detection threshold of these Cerenkov counters. To estimate the contribution of $\gamma$ rays we compared the energy yields measured by the Cerenkov counters for various thicknesses of the radiators and the filters. Measurements with aluminum filters ranging in thickness from 0.02 to 0.2 mm and with polymethyl methacrylate radiators 2 and 55 mm thick established that the $\gamma$ contribution did not exceed 1%.

The energy carried off by the electrons from the laser plasma was measured during the bombardment of spherical-shell targets with a high-aspect ratio, $R/\Delta R > 10^2$ ($R$ is the radius and $\Delta R$ is the shell thickness). The targets ranged in diameter from 0.35 to 0.45 mm. The bombarding laser pulses had a length $\sim 2$ ns, an energy from 500 to 1100 J, and a power density up to $10^{14}$ W/cm$^2$. The fraction of the laser energy deposited in the target in these experiments ranged from 35% to 45%. The experimental results are shown in Fig. 1. The energy yield falls off significantly with increasing cutoff energy, which was varied from 200 to 390 keV. The scatter in the values of the electron energy yield at a given cutoff energy can be attributed to differences in the parameters of the laser shots, e.g., the energy of the laser pulse, whose value (in joules) is given beside the experimental points (Fig. 1). The absolute energy yields shown here are calculated under the assumption of a spatial isotropy, as indicated by the agreement of the energy yields measured simultaneously along different

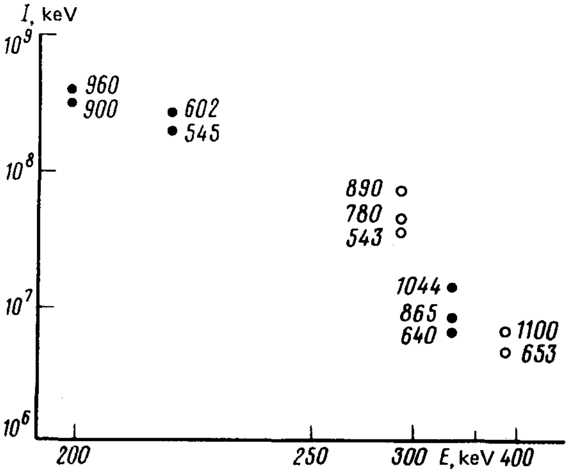

FIG. 1. Energy carried off by the electrons vs the cutoff energy $E$. ●—Polymethyl methacrylate radiator 50 mm in diameter and 55 mm high; ○—water radiator 18 mm in diameter and 55 mm high.

locations ($\sim\pi/2$) by two polymethyl methacrylate counters. This is a natural assumption in view of the rather high symmetry of the spherical bombardment in this experiment. An estimate puts the effective plasma temperature for these electrons above 40 keV, or well above the temperature corresponding to the superthermal electron component.

In conclusion, we should point out that the observed electron emission is of interest for the diagnostics of laser plasmas. It may carry some relatively undistorted information about the plasma state directly in the region in which these electrons are produced, because of the high penetrating ability of electrons at this energy.

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