Direct acceleration of electrons from ultrathin foils for diagnostics of Laser pulse focused by off-axis parabolic mirror

1,2Vais O.E., 1Bochkarev S.G., 3Ter-Avetisyan S., and 1,2Bychenkov V.Yu.

1Lebedev Physical Institute, Russian Academy of Sciences, Moscow, Russia,  
 [ovais@lebedev.ru](mailto:ovais@lebedev.ru),  
2Dukhov All-Russian Research Institute of Automatics, Moscow, Russia  
3Gwangju Institute of Science and Technology, Gwangju, Republic of Korea

Current laser technologies aimed at ultra-short laser pulse generation allow a high space and time energy concentration at the tight (ultra-tight) focus volume. As laser fields reach a relativistic level, conventional techniques of the laser pulse characteristic measurement become difficult that makes development of new methods topical. One of the possible methods is based on the measurement of electron characteristics that were directly accelerated in the process of laser pulse interaction with rare gas or ultrathin foils [1]. The theoretical models usually consider the paraxial approximation for the laser pulse description, but the tight focusing case is out of its applicability conditions. The solutions of the Helmholtz equation can be used for an accurate laser pulse description, including the solution constructed with the help of angular-spectrum method for a thin lens [2] or Stratton-Chu integrals for a parabolic mirror [3]. The development of a practical scheme for the field description is of reasonable interest for the diagnostic of powerful laser radiation characteristics.

In the current work we propose theoretical bases of the new method for the laser pulse diagnostic by means of the direct electron acceleration. Unlike most investigations, our approach is based on a realistic model of laser pulse focusing by an off-axis parabolic mirror. The solution was made for typical mirror sizes by the exact Stratton-Chu integrals that admit the description at the diffraction limit. The test particle method was used for electron dynamic calculations; it is justified for negligible plasma fields compared with laser field. Such approach is applicable when the laser radiation is focused into rare gas or thin (ultrathin) foil. Angular-spectrum distributions of accelerated particles were obtained depending on the focal laser intensity, focus tightness, temporal and spatial profiles that allows to determine laser intensity and quality.

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References

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