Application of multiple scattering theory to Doppler velocimetry of ejecta from shock-loaded samples

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The presentation addresses the actual problem of recovering the physical parameters of ejecta from data of heterodyne Doppler velocimetry (see, e.g., [1–3]). The spectral profile $J(\omega)$ of heterodyne beats underlies our analysis of experimental data. Under the assumption that ejected fragments are randomly spaced and their number within the probed volume is great, the noise-free component of $|J(\omega)|^2$ is shown to be expressed in terms of a solution to the transport equation for the field correlation function which accounts for multiple scattering and absorption of the probing beam in the cloud of moving particles. This provides a means of theoretical modeling of experimental Doppler data.

The ejecta cloud is considered a plane layer of particles moving in the air away from the free-surface. The spatial profile of the extinction coefficient and the cloud thickness are related directly to the distribution of ejected particles over velocities and coordinates. The slowing-down of ejected particles in the air leads to an ambiguous relation between the particle position and its velocity at different moments of time, resulting in essential complication of this distribution. We calculate the particle distribution over velocities and coordinates using a multi-group representation.

In the report we give a generalization of the results in [3] with allowance for the multi-group representation of the ejecta cloud. In this case the transport equation is reduced to a system of linked Milne-like equations. Furthermore, a finite radius of the probing beam is considered. We solve the system numerically with a discrete ordinate program. The spectrum of the backscattering signal is calculated with the discrete Fourier transform. Varying the values of the cloud optical thickness and the parameters of the particle distribution over velocities and sizes, we fit the calculated spectrum to the time-resolved data of heterodyne Doppler measurements. This approach enables us to recover the primary ejecta characteristics (the density–velocity profile, the total ejected mass, and the size distribution of ejected particles) directly from optoheterodyne experiments.

An application of the proposed method to the velocimetry data on ejecta from metal samples is presented.

References

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