Simulation of shock-waves in water induced by nanosecond-laser pulse

M. Kubečka, A. Obrusník, Z. Bonaventura

1 Department of Physical Electronics, Faculty of Science, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

One of the main advantages of using the nanosecond-laser pulses for generation of fast breakdown of water is to avoid the presence of metal-liquid interface. The laser-produced breakdown is well known phenomenon that generates shock-waves in liquid. The main physical mechanisms responsible for shock-waves in liquid by laser pulse were found to be linear optical absorption with subsequent bulk thermal expansion, explosive evaporation and dielectric breakdown and ionization [1, 2].

We study this acoustic phenomenon by simulating the generation of shock-waves using hydrodynamic model for motion of compressible liquid (water) described by equation of continuity for mass, momentum equation and the Tait equation [3]

\[
\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{u}) = 0
\]

\[
\rho \left[ \frac{\partial \vec{u}}{\partial t} + (\vec{u} \cdot \nabla) \vec{u} \right] = -\nabla p + \eta \left[ \nabla^2 \vec{u} + \frac{1}{3} \nabla (\nabla \cdot \vec{u}) \right]
\]

\[
p = (p_0 + B) \left( \frac{\rho}{\rho_0} \right)^\gamma - B
\]

where \( \rho \) is the fluid density, \( p \) is the pressure, \( \vec{u} \) is the velocity, \( \eta \) is the dynamic viscosity, \( B \) is the compressibility of the liquid and \( \gamma \) is a material parameter.

The aim of our work is to simulate the propagation of shock-wave to reconstruct numerical Schlieren images for comparison with experimental data.

Acknowledgements

This research has been supported by the Czech Science Foundation grant no. 18-04676S.

References