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

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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 ρ is the fluid density, p is the pressure, $\vec{u}$ is the velocity, η is the dynamic viscosity, B is the compressibility of the liquid and γ 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

[1] B. D. Strycker, et al., Optics express **(21)**, 20 (2013)

[2] F. V. Bunkin, A. A. Kolomensky, V. G. Mikhalevich, Lasers in Acoustics **(12)** (1991)

[3] M. N. Shneider, M. Pekker, Physical Review E **(87)**, 4 (2013)