Dynamics of shock-plasma interactions of ns laser induced air plasmas: Experimental Visualization vis-a-vis Numerical simulation

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Atmospheric plasmas due to laser induced breakdown (LIB) of ambient atmospheric air[1-5] have become interesting systems to generate micro-shocks in air,[1] study laser ablative propulsion systems,[2] sources of RF [3,4] and acoustic emissions[5,6] to name a few. The role of electron thermal plasmas on the shock waves,[7] different absorption mechanisms and equation of state[8,9] has brought out the necessity to relook and validate the numerical predictions with experiments. In this regard, we present the evolution and interaction dynamics of plasmas and shockwaves due to a 7 ns laser induced breakdown (LIB) of ambient atmospheric air[1-9] under two different configurations. First one from the two counterpropagating shockwaves generated by two collinear laser induced air plasmas of equal and unequal energies.[10] In the second scenario, the plasma is confined radially in a glass cavity of different aspect ratios which showed explicit compression of the plasma core.

The spatio-temporal evolution of the sequential processes such as, (i) the evolution of the primary shock wave (PSW) and their interaction with the plasma Core (PC), (ii) interaction two counter propagating PSWs inside PC and their multiple reflections, (iii) visualization of shock-plasma interaction leading to a jetlet formation (iv) the modification of the self-emission due to shock-plasma interaction (v) compression and splitting of the plasma into multiple lobes will be discussed.

A one-on-one correlation between the experimental visualizations and the numerical simulations were studied using two-dimensional FLASH radiation hydrodynamic code to elucidate on the role of laser pulse energy on (a) the compression of plasma core leading to modified the morphology of the plasma by the counter propagating PSWs, (b) the evolution of shock diamonds (c) longitudinal expansion of the plasma with tuneable enhancement of the plasma electron temperature and number density.[11] A combination of these studies has a potential to give a better insight into the industrial applications such as laser shock peening, where in the confinement of plasma plays a major role in enhancing the shock pressure impulse to be delivered to the target. Initial studies in this direction with a possibility to generate laser induced flyer plates will be briefly touched upon.[12]

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