Detachment regimes in laser droplet generation

Andrej Jeromen & Edvard Govekar

University of Ljubljana, Faculty of Mechanical Engineering, Laboratory of Synergetics, Aškerčeva 6, SI-1000 Ljubljana, Slovenia
andrej.jeromen@fs.uni-lj.si

The laser droplet generation is a process where the tip of the vertically fed metal wire is melted by a laser pulse. The outcome and the dynamics of the process of sequential droplet generation is governed by detachment of pendant droplet that can be influenced by numerous process variables. The complexity of this engineering process is additionaly increased by the interaction between the laser pulse frequency and the dynamics of a pendant droplet.

A series of experiments is presented where the frequency of the square laser pulses was varied keeping both the average laser power and the feeding speed of the metal wire constant. Depending on the decreasing laser pulse frequency from 300 Hz to 50 Hz three different detachment regimes accompanied by different dynamics have been identified: a) dripping, caused by the force of gravity alone, b) resonant detachment, caused by a combination of the gravity force and the laser induced normal oscillation modes of the pendant droplet, and c) break-up caused by the Rayleigh-Plateau instability. The observed regimes are characterized based on the geometrical properties of the generated droplets and the time series generated from the high speed IR camera records. Dripping can experimentally be characterized as a periodic droplet detachment with larger droplet volume of low scatter. Decreasing the laser pulse frequency leads to a decrease of the periodically detached droplets volume and a transition to resonant detachment which is observed at 150 Hz. At this frequency a periodic detachment with the lowest scattering of the detached droplets volume is identified. Further decreasing the frequency leads to the transition to break-up droplet detachment regime where the smallest droplets are observed while the droplet detachment and corresponding droplet volume become very irregular. The frequency of 150 Hz that corresponds to the lowest observed droplet volume scattering presumably coincides with the half of the normal droplet oscillation mode frequency $f_{l=2}$.