Laser-induced condensation in the atmosphere: Mechanism and optimization

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The filamentation of ultrashort laser pulses [1] attracts considerable interest due to its potential applications in remote sensing technologies, free space communications as well as weather diagnostics and modulation systems. They generate a plasma wake that modifies the physico-chemical properties of the air, allowing the condensation of aerosol particles in sub-saturated air. [2,3] This phenomenon is promising as a technique for analyzing and possibly modifying the behavior of clouds. [4]

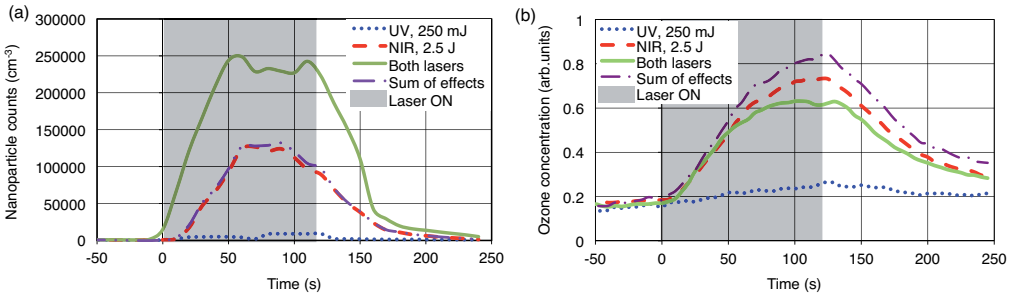

Figure 1: (a) Evolution of the concentration of (a) nanoparticles and (b) ozone under single- or dual NIR-UV-pulse (10 ns delay) illumination, in the case of a collimated UV beam with ~1 cm diameter. The sum of the individual effects of the NIR and UV pulses is also given for reference. [6]

Practical applications of such effects requires to reach a macroscopic effect to increase the yield of condensed particles. We show that using ultraviolet (UV) beams drastically enhances the yield in laser-induced nanoparticle condensation. [5] This enhancement is even more spectacular when combining a multiple filamenting (60 TW) near-infrared laser with a high intensity UV beam. In this case, we observe an unexpected cooperative effect of the two lasers, increasing the production of nanoparticles beyond the sum of the effects of the individual beams. (Figure 1). We attribute the cooperative effect to the production of ozone by the NIR pulses, followed by its UV photolysis, yielding OH radicals. [6]
Furthermore, detailed analysis of the laser-generated particles shows that they are mainly composed of water, nitrogen compounds, and to a lesser extent of oxidized volatile organic species.

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