# How can time-resolved experiments contribute to a validated model of ultrashort pulse laser ablation?

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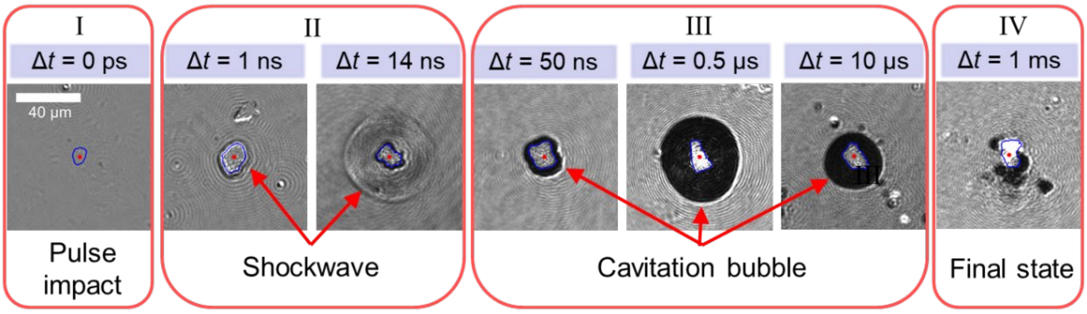
In recent decades, ultrafast laser ablation has been extensively studied. Numerous simulations exist today that primarily provide a qualitative understanding of laser ablation with single pulses, while the precise quantitative prediction of final state and time-resolved observables remains challenging. Moreover, most experimental approaches to study laser ablation are performed with multiple pulses, making it difficult to experimentally validate single-pulse simulations.
Final state observables that may be predicted by simulations include ablation threshold, efficiency, and morphology [1,2]. Pump-probe techniques can measure time-resolved observables with a femtosecond temporal resolution up to the final state within several hundreds of µs [3]. When pressure waves become visible in pump-probe microscopy, such as during laser ablation in liquids, also pressure amplitudes can be measured [4,5]. These observables can be used to test theoretical models and gain insight how pulse duration, separation, and fluence affect the efficiency of ablation and how photo-mechanical and photo-thermal mechanisms contribute to the process.
Here, we present new experimental validation of models for laser ablation in air and liquid [1] as well as for laser fragmentation of microparticles.




As an example, we are able to highlight the strong photo-mechanical nature of laser fragmentation of iridium oxide microparticles immersed in water [5] by pump-probe microscopy, from which we can measure the pressure and energetics of the shockwave in and outside the particle.

**Acknowledgements**: The authors gratefully acknowledge financial support by the Deutsche Forschungsgemeinschaft under project numbers 428973857, 428315411 and 528706678.

**References**: [1] C. Chen, L. Zhigilei, Appl. Phys. A **129** 288 (2023); [2] D. Redka, J. Winter, C. Gadelmeier, A. Djuranovic, U. Glatzel et al., Appl. Surf. Sci. **594** 153427 (2022); [3] S. Rapp, M. Kaiser, M. Schmidt, H.P. Huber, Opt. Expr. **24** 17572 (2016); [4] M. Spellauge, C. Doñate-Buendía, S. Barcikowski, B. Gökce, H. Huber, Light Sci. Appl. **11** 68 (2022); [5] M. Spellauge, M. Tack, R. Streubel, M. Miertz, K. Exner, S. et al., Small 2206485 (2023)