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From optimally controlled photoassotiation experiments on ultracold atoms to the controlled formation of plasma filaments in air

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The use of optimally shaped, femtosecond laser pulses has opened fascinating perspectives for the direct, real time control of numerous ultrafast light-induced processes. First we will concentrate on the characterization and optimization of elementary molecular processes like photo-association, -dissociation, -ionization and -detachment, which we applied on very cold alkaline atoms in a magneto-optical trap (MOT), and on small metal clusters in the gas phase. Different phase, amplitude and polarisation modulation schemes will be presented. Pulse cleaning and parametrisation routines were employed, in order to retrieve from the obtained optimized pulse shapes a maximum of information about the system and the selected dynamical path. Also ways of handling the optimization algorithm in case of conflicting objectives will be discussed. Then, first exploratory experiments of using modulated white light pulses will be presented.

The mentioned white light pulses are extracted from plasma filaments, which again are optimized by using optimally shaped laser pulses: in the laboratory and at large distances in the atmosphere. Schemes for their optimization, modulation, characterization and application will be presented. Feedback loops were for example successfully installed for performing remote LIBS-experiments (Laser Induced Breakdown Spectroscopy), that allowed the characterization of metal targets at distances over 100 metres. Further applications in the field of pollution and aerosol detection, as well as lightning protection will be discussed.