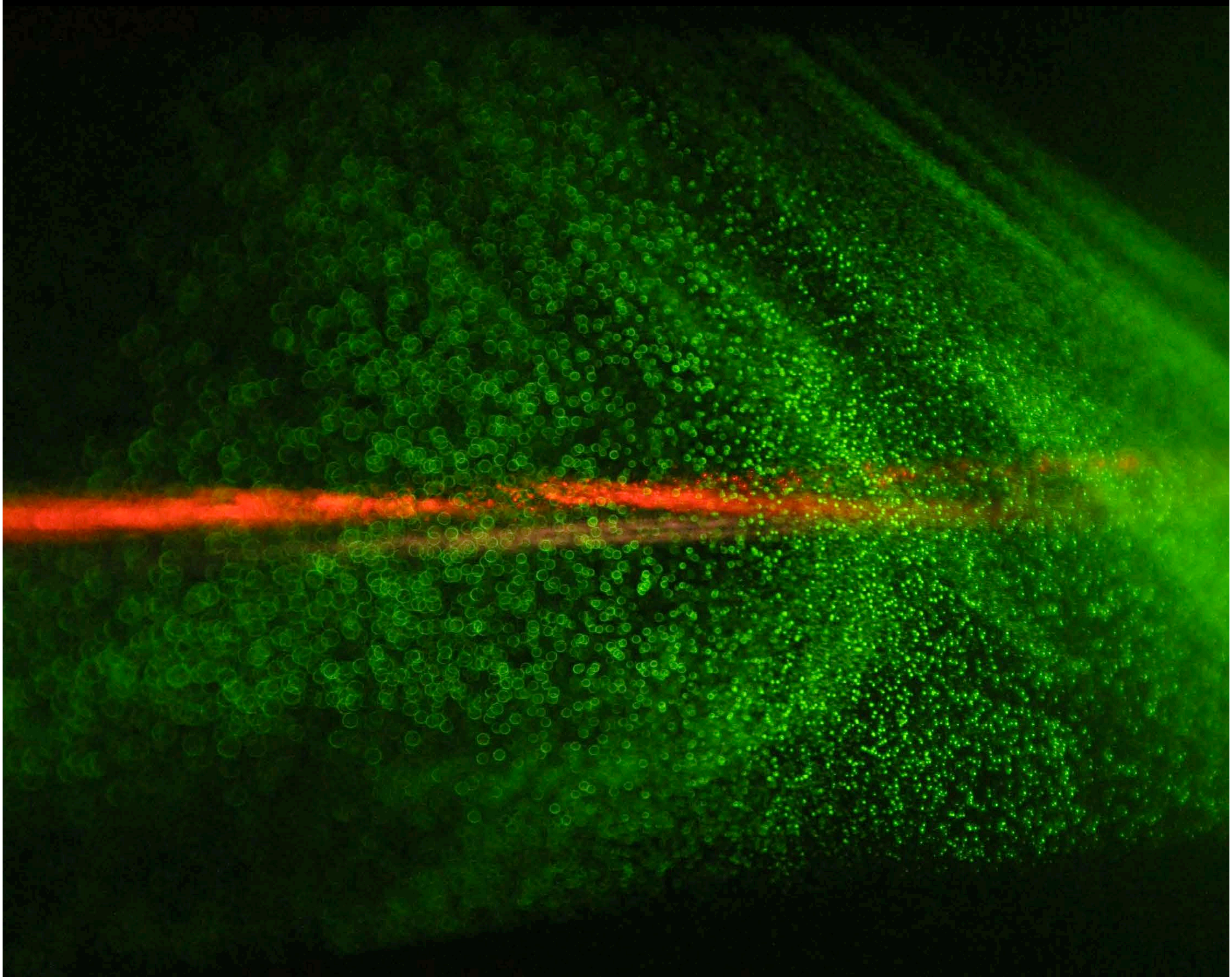
LWC2015

Conference on Laser, Weather, and Climate 2015

Geneva, 21-23 Sept. 2015



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Welcome

As highlighted by the success of the first two Conferences on Laser, Weather, and Climate in 2011 and 2013, ultra-short lasers launched into the atmosphere have emerged as a promising prospective tool for weather modulation and climate studies. Such prospects include lightning control and laser-assisted condensation, as well as the striking similarities between the non-linear optical propagation and natural phenomena like rogue waves or climate bifurcations.

Although these new perspectives triggered an increasing interest and activity in many groups worldwide, the highly interdisciplinary nature of the subject limited its development, due to the need for enhanced contacts between laser and atmospheric physicists, chemists, electrical engineers, meteorologists, and climatologists.

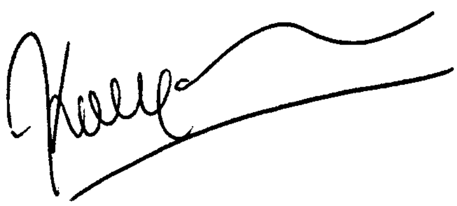
Further strengthening this link is precisely the aim of the third Conference on Laser, Weather and Climate (LWC2015) at the World Meteorological Organisation (WMO) in Geneva, gathering the most prominent specialists on both sides for tutorial talks, free discussions as well as networking.

Let's go on building together a new community dedicated to laser-based weather modulation.

We look forward to welcoming you in Geneva!

Jean-Pierre Wolf   Jérôme Kasparian

LWC2015 co-chairs



General information

Access

The conference will be held at the World Meteorological Organization (WMO), 7 bis, avenue de la Paix, 1211 Geneva 2, Switzerland.

The conference location is connected directly by bus to

- the airport: Bus 28, direction Jardin Botanique, get off at the last station. 15 minutes ride, one bus every 20 minutes. Note that you can get a free bus ticket at the exit of the baggage claim.
- the main train station (Cornavin): Bus 1, direction Jardin Botanique, get off at the last station. Tickets are sold at the "TPG" bus office at the train station or at ticket-vending machines at each bus stop.

Accommodation

There are several high-standard hotels close to the conference location: See on WMO's web site for hints about accommodation and the stay in Geneva.

http://www.wmo.int/pages/prog/www/Geneva-info.html

Conference fees

Each participant, except invited speakers, will be charged 200 CHF to cover the expenses of the conference.

The conference fees include the access to the conference, the book of abstracts, and the coffee breaks. They do not include the meals, which can be paid directly at the WMO cafeteria, nor the conference dinner, that will be charged separately.

Deadlines

July 31: Participant Registration & Abstract submission

The Conference

Conference format

The purpose of the conference is to facilitate the contacts and sharing of ideas between researchers from different communities, including specialists of both the atmosphere and laser physics. Invited talks of 20 minutes followed by 10 minutes of discussion will allow this sharing.

More targeted results will be presented as posters. To help establishing contacts, each poster will be briefly presented orally in a dedicated plenary session at the beginning of the poster session.

Furthermore, long coffee and lunch breaks will offer time for informal discussions

Preliminary Program

Monday, September 21st

09:00 Registration and welcome

10:00 Welcome address

10:30 Session 1: Guiding high-voltage discharges and lightning – 1 – Ludger Wöste, Chairman

J. Moloney - *Super High Power mid-infrared Femtosecond Light Bullet*

M. Clerici - *Laser-guiding electrical discharges around obstacles*

A. Houard - *Interferometric study of low density channels and guided electric discharges induced in air by laser femtosecond filaments*

12:00 Short poster presentations – 3 min each

12:30 Lunch break

14:00 Session 2: Guiding high-voltage discharges and lightning – 2

A. Zigler - *Long, high density plasma wire generated in air by femtosecond laser filamentation*

J.-C. Diels

J. Kasparian - *Remote Neutralization of High-Voltage by Laser Filamentation*

15:30 Coffee break & Session 3: Posters

17:00 Free discussions

Tuesday, September 22nd

09:00 Session 4: New filaments for the atmosphere – 1

F. Légaré - *Frequency domain Optical Parametric Amplification*

V. Shumakova - *Far above the critical power of self-focusing: generation and filamentation of few-cycle mid-IR pulses*

T. Metzger - *Picosecond Thin-Disk Amplifiers*

10:30 Coffee break

11:00 Session 5: Aerosols and laser-induced condensation - 1

S. L. Chin - *Femtosecond laser filament induced snow fall*

J. Slowik - *Investigation of ambient and laboratory-generated secondary organic aerosol using aerosol mass spectrometry*

D. Mongin - *Non-linear photochemical pathways in laser induced atmospheric aerosol formation*

T. Leisner - *Filament- Aerosol- Interaction in the Atmosphere*

12:30 Lunch break

14:30 Session 6: Climate bifurcations

M. Beniston - *Thresholds in the climate system*

S. Bathiani - *Simple tippings or complex transitions? On the potential for future abrupt climate change*

15:30 Coffee break

16:00 Session 7: Laser and rogue waves

M. Brunetti - *Modulational instability in forced regimes*

G. Steinmeyer - *On the origin of ocean rogue waves*

H. Branger - *Modulational evolution of water-waves at the atmosphere-ocean interface: some similarities with non-linear optics*

17:00 Free discussions

19:00 Conference Dinner

Wednesday, September 23rd

09:00 Session 8: Aerosols and laser-induced condensation - 2

Jiangsheng Liu - *Laser-induced airflow, water condensation and snow formation in a cloud chamber*

M. Matthews - *Combined effect of UV and NIR beams in laser-induced condensation*

T. J. Wang - *Laser guided corona discharges*

M. Richardson - *Fundamentals of laser interaction with water droplets*

11:00 Coffee break

11:30 Session 9: New filaments for the atmosphere - 2

P. Béjot - *Subcycle engineering of laser filamentation in gas by harmonic seeding*

W. Ettoumi - *Multiple filamentation as a grid of rigid rotators*

12:30 Concluding remarks

13:00 Lunch break

15:00 Laboratory visit and free discussions

Super High Power mid-infrared Femtosecond Light Bullet

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The transportation of high power, ultrafast, compact and self-sustaining electromagnetic pulses over long distances in the atmosphere constitutes one of the long-term problems in multiple areas in science, such as remote atmospheric sensing, remote optical power delivery, and wireless optical telecommunications. The seemingly unavoidable breakup of a high power wavepacket over long distances, due to modulation instability, constitutes the main limitation in the majority of long-range high-power optical applications. We reveal a new paradigm for long range low-loss, ultra-high-power ultrashort pulse propagation at mid-infrared wavelengths in the atmosphere[1]. Prior to the onset of critical self-focusing, energy in the fundamental wave continually leaks into shock driven spectrally broadened higher harmonics. A persistent near-invariant solitonic leading edge on the multi-TW pulse waveform transports most of the power over hundred meter long distances. Our results are expected to spark extensive research in optics, where the use of mid-infrared lasers is currently much underutilized.

Ultrafast femtosecond laser pulses possess the unique property that they deliver extreme local fields, avoid avalanche ionization and yet deposit relatively little energy thereby avoiding significant collateral damage. In the context of long range atmospheric propagation of multi-TW femtosecond duration laser pulses, the Ti:Sapphire laser has been the standard workhorse and has promoted atmospheric studies ranging from femtosecond LIDAR, remote LIBS, white light generation, discharge triggering and guiding, lightning control[2] and filament induced water-cloud condensation in the free, sub-saturated atmosphere[3].

The physics is fundamentally different from that observed at 800nm with the emergence of a new type of singularity. The initial self-focusing phase mimics that predicted by the Nonlinear Schrödinger Equation (NLSE) or related nonlinear envelope equations, namely, the onset of critical self-focusing collapse. However a new type of singularity emerges whereby a carrier shock wave leads to collapse-accelerated self-steepening of the optical carrier wave well before ionization can generate a sufficiently strong defocusing lens across the beam. The steep shock front generates a featureless spectrum encompassing all even and odd harmonics. These being at shorter wavelengths, propagate as wavepackets away from the fundamental at a different group velocity. Group velocity dispersion, although weak, is critically important in regularizing the steep shock front developing on the carrier wave. The result is that a high energy light bullet is sustained for long propagation paths because recurrent multiple carrier wave shock steepening events initiate bursts of spectrally broadened emissions at the back of the main pulse that act to temporally soften the shock front [see Figure 1].

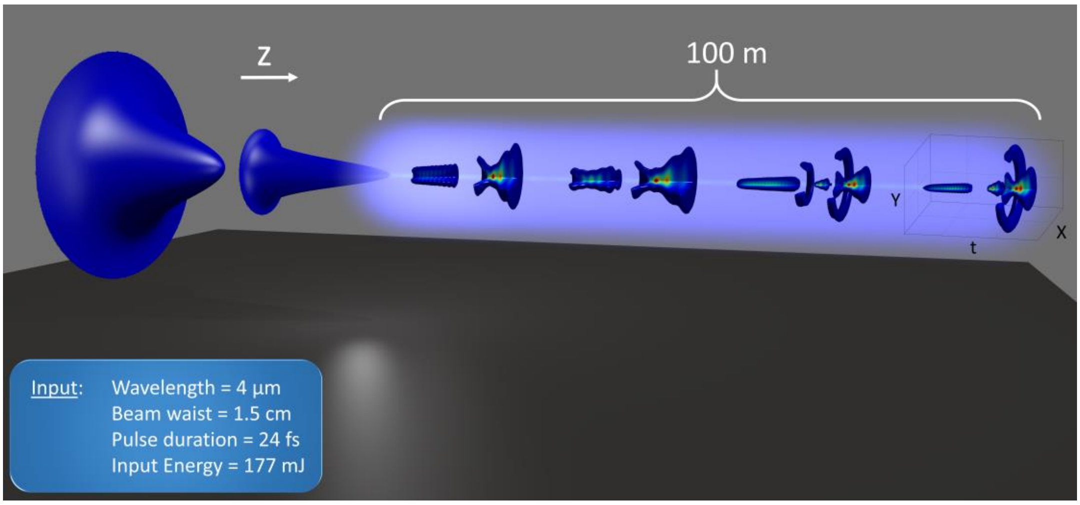

Figure 1. Schematic of the onset of self-focusing to create a self-sustaining light bullet propagating over a 100 m path in air.

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Laser-guiding electrical discharges around obstacles

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Electric discharges have a large impact on our daily life and the possibility to control them with intense lasers is a long-standing goal of the photonics community. Laser protection from lightening is for instance one of the most attractive applications of charge laser guiding (see e.g. [1–3]), which has to face the challenge of guiding currents over extremely long distances. Yet, electric arcs play a crucial role in modern technology also on the short spatial scale. Sparks are used to ignite the fuel in combustion engines [4] and play a relevant role in machining and potentially, also in milling [5–7]. Moreover a fine control of the temporal dynamics of laser triggered electric discharges may also be of great impact for high-voltage switches (see e.g. [8]).
Here we show that beam shaping can boost our ability to control the properties of laser driven electric discharges, resulting in propagation of the current along nontrivial trajectories, e.g. avoiding obstacles, and also modifying the temporal dynamics of the current transient.
We compare the spatial and temporal properties of electric discharges triggered by different laser beams, e.g. Gaussian, Bessel and Airy, on the short 5-10 cm spatial scale and we discuss the results and their potential impact.

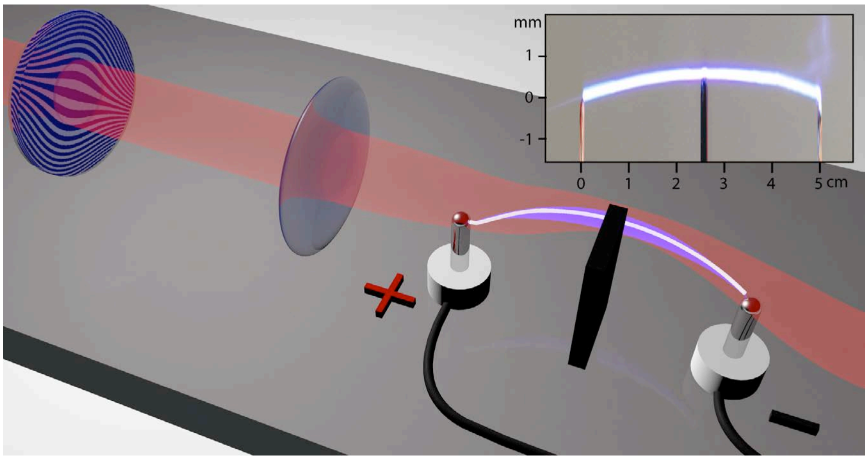

Figure 1. Example of an electric discharge triggered and guided by an Airy beam. The discharge follows the curved trajectory of the main peak of the optical pulse, avoiding an obstacle placed in the line of sight of the electrodes (the inset shows the actual measurement).

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Interferometric study of low density channels and guided electric discharges induced in air by laser femtosecond filaments

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In the last decade femtosecond laser filaments has proved to be a powerful tool to trigger and guide electric discharges in atmospheric air with gap length reaching several meters [1-3]. The weakly ionized plasma column and subsequent low density channel generated by the laser filament allow the precise triggering and guiding of electric discharges between two electrodes with a significant reduction of the breakdown voltage [4-5]. This effect is particularly promising due to its potential opening for the laser lightning rod [6-7], high-voltage, high-current switches [8], or virtual plasma antennas [9].

Using transverse interferometry and acoustic measurements we have studied the formation of underdense channels in air by femtosecond laser filaments with energy ranging from 1 to 160 mJ. The influence of the laser parameters such as input energy, pulse duration and numerical aperture has been analyzed [10]. The maximum depth of the underdense channel observed is about 65% with respect to air density. For input energy higher than 5 mJ, the depth remains constant but the diameter of the channel is increased.

With a two-color version of the interferometer, we have also observed the temporal evolution of centimeter scale filament guided electric discharges [11]. Using different generators and electric circuits, AC and DC discharges regimes have been compared, and discharges currents with duration ranging from 100 ns up to 1 ms have been tested.

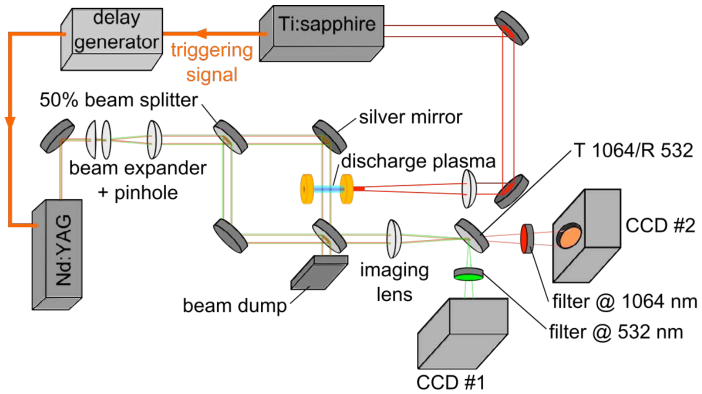

Figure 1. Experimental setup for the interferometric study of filament guided discharges.

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Long, high density plasma wire generated in air by femtosecond laser filamentation.

J. Papeer, R.Bruch, E. Dekel, O. Pollak, M. Botton, Z. Henis and A. Zigler

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Self-guided propagation of high power laser pulses in air is a complex, nonlinear phenomenon known as laser beam filamentation. Its description requires the use of many disciplines in physics including nonlinear optics, plasma physics and air chemistry. The high laser intensity (10^{13}W/cm^2) in the filaments core ionizes the air and leaves a plasma channel with a 100µm diameter and an electron density of ~10^{16}cm^{-3} in its wake. One of the most promising applications is the use of the conducting properties of the plasma channel left in the wake of the high laser power pulse to trigger electrical discharges or guide an electrical current, however an experimental demonstration of electrical guiding over the distance of many meters is still absent. There are several reasons for the difficulty to successfully guide electrical discharges over a distance longer than few meters. The first is the short lifetime of the plasma left in the wake of the laser pulse due to the plasma recombination over a typical timespan of a few nanoseconds. In this talk we will demonstrate experimentaly that this limitation can be overcome by introducing an additional, long (ns) laser pulse to the beam[1]. This secondary nsec laser pulse heats the plasma generated by the filament and extends the plasma lifetime by more than an order of magnitude thus allowing the head of the channel to propagate a distance greater then 10m before the tail of the channel recombines.
The second obstacle limiting the length of the plasma channels is the length limitation of self guided propagation of each filament[2]. The length of the plasma filament is limited by the energy combined in the filament and capability to replenish it from surrounding laser beam energy[3]. In this talk we will experimentally demonstrate a solution to this feature. We concatenate several high-density plasma filaments thus generating a long "broken" plasma channel consisting of several plasma channels. In our proof of principle experiment we used a 1TW laser system to successfully combine three filaments, each one ~1m long. By doing so we effectively generate a ~3m "broken wire" high electron density (above 10^{15}cm^{-3}) plasma channel. Our approach can be easily extrapolated to larger distances by using more powerful laser systems. For example, a 100TW laser system, may accommodate enough power to concatenate many tens of filaments, producing the opportunity to generate plasma channels of several tens of meters long. In our approach the length of a plasma channel can be scaled up linearly with the laser power, in comparison to other approaches that manage to extend the filamentation length but still have inherent limitations on the final length of the filament.

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Remote Neutralization of High-Voltage by Laser Filamentation

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Laser filaments constitute a self-guided propagation regime of high power for ultrashort pulses [1]. As they propagate unaffected through perturbed atmospheres, they have been proposed as candidates for atmospheric applications including the control of high-voltage discharges and lightning [2,3,4]. Laser filaments have also been used as probes to investigate the dynamics of high-voltage discharges and leaders.

However, until now, the triggering of high-voltage discharges by lasers has always been investigated with pulsed high-voltage generators. In real atmospheric conditions, the charge of thunderclouds evolves slowly, so that it is best modelled by a DC high-voltage source. We therefore investigated the interaction of laser filaments with a field maintained between two electrodes some tens of cm apart.

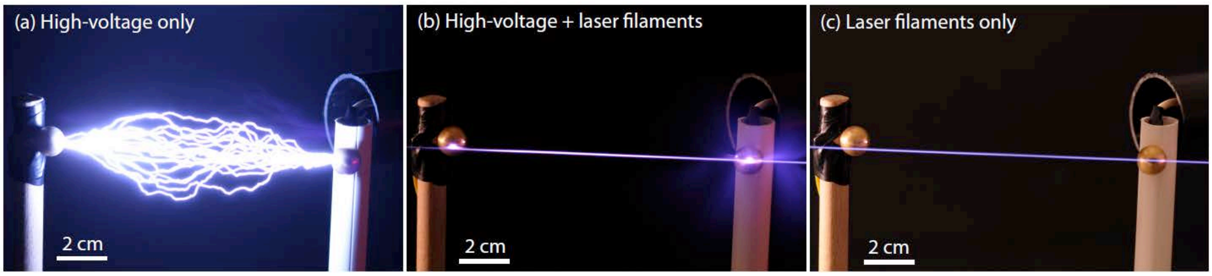

Figure 1. Electrical arc suppression by laser-induced neutralization under 100 kV. (a) Electrical arcs without laser; (b) Arc inhibition when the filamenting laser is turned on; (c) laser filament alone

We show that laser filaments trigger current bursts of moderate intensity (few Amperes) between two electrodes. Remarkably, this effect persists when the electrodes are moved away from the laser filament, up to at least 30 cm.

As a result, the laser filaments neutralize the high-voltage electrode within tens of seconds to a few hours, depending on their distance to the electrodes. The resulting voltage drop leads to the suppression of sparks in conditions where they would occur without laser. This remote neutralization strongly contrasts with the triggering of sparks by lasers in contact with the electrodes and synchronized with high-voltage pulses.

Unlike the previous works which focused on the triggering and guiding of discharges, so as to actively divert lightning strikes to locations where they would be harmless, such results open new fields of investigation for the use of laser filaments to discharge high-voltage sources.

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Frequency domain Optical Parametric Amplification

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The universal dilemma of gain narrowing (the more one amplifies a laser pulse, the longer its duration gets) occurring in fs amplifiers prevents ultra-high power lasers from delivering few-cycle pulses. This problem is overcome by a new amplification concept: Fourier domain Optical Parametric Amplification – FOPA [1,2]. It enables simultaneous up-scaling of peak power and amplified spectral bandwidth and can be performed at any wavelength range of conventional amplification schemes, however, with the capability to amplify single cycles of light.

The key idea for amplification of octave-spanning spectra without loss of spectral bandwidth is to amplify the broad spectrum "slice by slice" in the frequency domain (see Fig. 1), i.e. in the Fourier plane of a *4f*-setup [3]. Opposed to traditional schemes where amplification takes place in time domain, we propose to amplify different spectral parts independently of each other in the spectral domain. Therefore, the pulse's input spectrum is spectrally dispersed and then several individual narrowband optical parametric crystals are used whereby each is tuned for optimal amplification of its corresponding spectral slice.

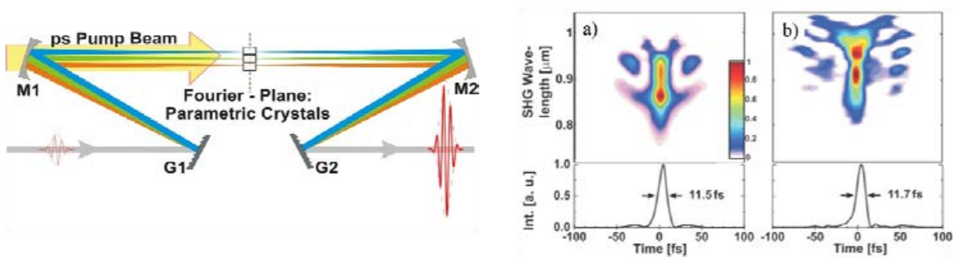

Figure 1. **Left:** In a Frequency domain optical parametric amplifier (FOPA), transform limited input pulses are spectrally dispersed in a symmetric *4-f* setup and remain transform limited after amplification. Different crystals in the Fourier plane can be optimized to amplify their corresponding wavelength slice. Phase matching bandwidth and output energy only depend on the number of crystals employed and are not limited by the material properties of laser crystal any more. **Right: (a)** SHG-FROG trace and corresponding temporal profile after the hollow core fiber setup. For more details, ref. [3]. **(b)** SHG-FROG trace and temporal profile of the 1.43 mJ 1.8 micron pulses amplified by FOPA. Temporal characteristics of the seed pulses are not modified by FOPA.

The striking advantages of this scheme, are its capability to amplify (more than) one octave of bandwidth without shorting the corresponding pulse duration. This is because ultrabroadband phase matching is not defined by the properties of the nonlinear crystal employed but the number of crystals employed. In the same manner, to increase the output energy one simply has to increase the spectral extension in the Fourier plane and to add one more crystal. Thus, increasing pulse energy and shortening its duration accompany each other.

A proof of principle experiment was carried out at the Advanced Laser Light Source (ALLS) on the sub-two cycle IR beam line [4] and yielded record breaking performance in the field of few-cycle IR lasers. 100µJ two-cycle pulses from a hollow core fibre compression setup were amplified to 1.43mJ without distorting spatial or temporal properties. Pulse duration at the input of FOPA and after FOPA remains the same, as demonstrated by the measured SHG-FROG traces presented in Fig. 1(a,b).

The conversion efficiency in the Fourier plane was about 14% for converting pump photons to Idler photons. The CEP stability of the input pulses was slightly increasing from an rms value of 340mrad to 450 mrad upon amplification. The FOPA output was used to drive HHG in a newly designed gas cell filled with neon. A collimated XUV beam was generated with a cut off extending up to 450 eV photon energy.

References

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Far above the critical power of self-focusing: generation and filamentation of few-cycle mid-IR pulses

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High energy mid-IR laser pulses are in demand in many applications of strong field physics, such as coherent and incoherent Xray generation, THz pulse generation from laser plasma, particle acceleration and femtosecond filamentation,—all of which profit from increasing the optical cycle duration of the driver pulse as a way of scaling ponderomotive energy. One of the fundamental challenges for mid-IR driver technology is the generation of multi-millijoule few-cycle pulses. Because of the limited bandwidth of optical amplifiers external pulse compression techniques are required. Fortunately, strong anomalous bulk dispersion in the mid-IR spectral range makes it feasible to realize a soliton-like nonlinear self-compression, whereby the negative group delay dispersion (GDD) of an anomalously dispersive nonlinear medium counteracts the positive GDD arising from self-phase modulation[1, 2]. However multi-millijoule few-cycle pulses carry peak powers on the order of hundreds of gigawatts, which in the case of transparent solid dielectrics exceeds the critical power of self-focusing (P_{cr}) by many orders of magnitude. Such conditions should unavoidably lead to modulation instability and spatial beam collapse preventing soliton-like nonlinear self-compression for millijoule pulses. Nonetheless, as experimentally and numerically shown in this contribution, it is possible to separate the length scales of nonlinear pulse compression and spatial beam collapse because of a favorable interplay between the strong anomalous dispersion and optical nonlinearity around the wavelength of 3.9 µm. As a result, we achieve a simple robust and low-loss self-compression of >20 mJ pulses to a sub-tree optical cycle pulse duration (Fig.1a).

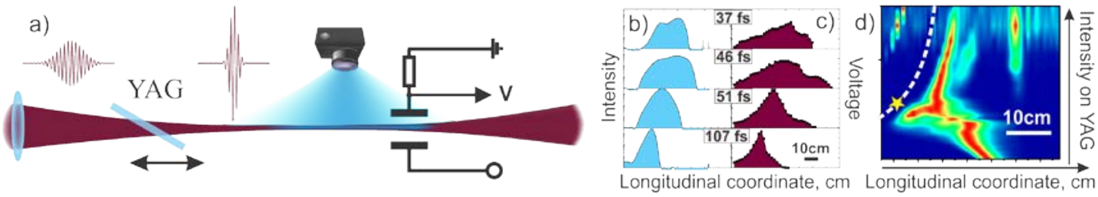

Figure 1. (a) experimental setup for studies of filamentation of self-compressed mid-IR pulses; (b) dependence of the luminescence from a filament on pulse duration (c) dependence of plasma density in a filament on pulse duration; (d) dependence of the luminescence from a filament on the intensity on an input surface of YAG plate; the position of YAG plate is indicated by a dashed line and the star corresponds to the shortest pulse duration at the exit face of YAG.

The self-compression boosts the peak power of mid-IR pulses to a record level of >650 GW. Using the known value of P_{cr} at 800 nm for atmospheric pressure air [3] and applying the λ^2 scaling law, we estimate that the peak power obtained at 3.9 µm should be about ×3 above the P_{cr} for ambient air. Surprisingly, our experimental evidence points out that the value of P_{cr} extrapolated from the 800-nm case is significantly overestimated. For experimental characterization of 3.9-µm-driven air filaments, we record the plasma density with a pair of movable electrodes and UV fluorescence with a photo-camera (Fig.1a). The degree of self-compression is controlled by the incident intensity on the YAG plate that is movable along the beam behind the focusing lens. With decreasing the pulse duration, the filament elongates and undergoes several refocusing cycles. At higher input intensities on the YAG plate, air filamentation sensitively depends on a combination of effects in YAG (growing ionization losses, temporal pulse splitting, change of the beam structure and divergence). In addition, numerical modeling suggests that the changes in the filamentation dynamics are not only caused by the differences in the self-compression dynamics in YAG but also by nonlinear propagation in air before the filament. By applying the semi-empirical Marburger equation [3] to the experimental data we determine $P_{cr}\approx 30$ GW at 3.9 µm 1 bar in air, which is nearly 10 times below the value extrapolated from the 800-nm data. Numerical modeling supports our experimental finding and suggests caution in the interpretation of conventionally determined values of P_{cr}.

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Picosecond Thin-Disk Amplifiers

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Lightning control in thunder clouds would benefit from higher energies and higher repetition rates by prolonging the plasma lifetime and enhancing the chance of triggering lightning strikes [1, 2]. Similarly in multi-spectral LIDAR, an increased repetition rate leads to a better signal strength of the back scattered light [3].The conventional high energy systems based on Ti:Sapphire or Yb:CaF_2 technology are limited to a few watts of average power. On the contrary, the thin-disk approach has shown an incomparable ability to reach both high average powers and pulse energies since its introduction in 1994 [4]. Due to its efficient one dimensional heat removal, the thin-disk exhibits low distortions and negligible thermal lensing even when pumped at extreme power densities of >10 kW/cm². Since the first few-ps kHz multi-mJ Yb:YAG regenerative amplifier based on the industrial TRUMPF Laser thin-disk technology in 2007 [5], the average power and pulse energy could be continuously increased. In 2012, TRUMPF Scientific Lasers was founded to push the limits of high energy ultra-fast thin disk amplifiers far beyond the state of the art. In 2013, a 300 W amplifier with pulse energies of 50 mJ and <2 ps pulse duration was demonstrated [6]. Recently at TRUMPF Scientific Lasers, regenerative amplifiers achieved >1 kW at 100 kHz, 350 W at 3kHz and 220 mJ at 1 kHz reaching the 0.1 TW level [7]. The latter was used in the laboratory for launching a 2.5-m long filament in air (Figure 1). Typically these laser systems consist of a seed oscillator, a fiber-Bragg-grating stretcher and a regenerative amplifier followed by a grating-based pulse compressor. Applying thin-disk technology in multipass amplifier configurations, other research groups have obtained >500 mJ at 100 Hz [8] and recently 1.4 kW at 300 kHz [9]. Furthermore thin-disk based multipass amplifiers have a great potential for increasing the energy and average power towards the Joule and Terawatt level with kilowatts of average power, while still maintaining a near-diffraction-limited TEM_{00} fundamental laser mode. Such amplifiers are built with industrial and well-engineered thin-disk technology without the need of cryogenic cooling or vacuum technology. This approach enables customized, robust and long-term stable configurations profiting from a fast and guaranteed spare-part service by the worldwide TRUMPF network.

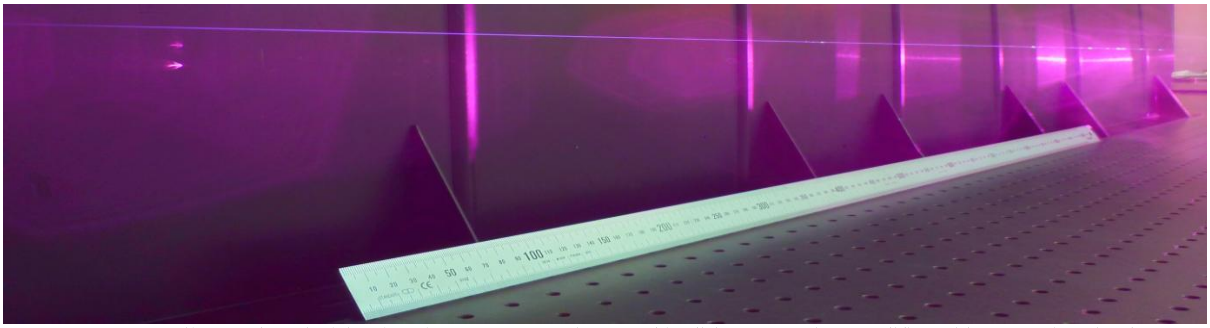

Figure 1. Filament launched in air using a 220 mJ Yb:YAG thin-disk regenerative amplifier with a wavelength of 1030 nm, 1 kHz repetition rate and <1.5 ps pulse duration. *Photograph by Thomas Metzger*

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Femtosecond laser filament induced snow/rain fall in a cloud chamber

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Femtosecond Ti-sapphire laser filamentation induced precipitation (snow or rain fall) in a cloud chamber has been observed in the Shanghai Institute of Optics and Fine Mechanics (SIOM) for the first time a few years ago. Some recent advances were made both in Laval University and in SIOM. This talk is my current understanding and interpretation of the physical processes leading to precipitation. Energy released from a relaxing filament zone in air would induce a strong local convection. A sustained convection would lead to turbulence. When this turbulence was created in a region with a strong temperature gradient inside a cloud chamber, super-saturation would occur; hence, precipitation.

Investigation of ambient and laboratory-generated secondary organic aerosol using aerosol mass spectrometry

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Atmospheric organic aerosol (OA) has important but highly uncertain effects on climate and health. These uncertainties are due in large part to the complexity of OA sources and processes governing its atmospheric evolution. OA is typically classified as either primary OA, which is directly emitted in the particle phase, or secondary OA (SOA) which is formed in the atmosphere from the reaction of gaseous precursors. These reactions are strongly influenced by atmospheric oxidants such as the OH radical. Laser filamentation in ambient air provides a highly oxidizing environment, leading to the formation of oxygenated OA (OOA). High-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS)[1] measurements suggest that this laser-produced OOA has a composition similar to that of ambient SOA.

HR-ToF-AMS measurements have been used in conjunction with novel statistical and experimental techniques in pursuit a quantitative and source/process-based description of SOA formation, properties, and evolution. Source apportionment techniques such as positive matrix factorization allow deconvolution of an ambient mass spectral time series into a set of mass spectra characteristic of major sources and processes[2]. Generation of SOA under controlled conditions can be attained in smog chambers, which allow batch aging of emissions at atmospherically relevant oxidant concentrations, or flow tube systems such as the potential aerosol mass (PAM)[3] system, which utilize higher-than-ambient OH radical concentrations to yield rapid, continuous SOA production. Detailed coupling and inter-comparison of these techniques provides an improved picture of SOA sources and aging and a framework for the interpretation of laser-generated OOA.

Results will be presented from a recent inter-comparison of PAM and smog chamber SOA generated from wood burning and biogenic precursors[4]. SOA composition will be compared to laser-generated OOA and long-term source apportionment results[5] from AMS-based measurements in Switzerland.

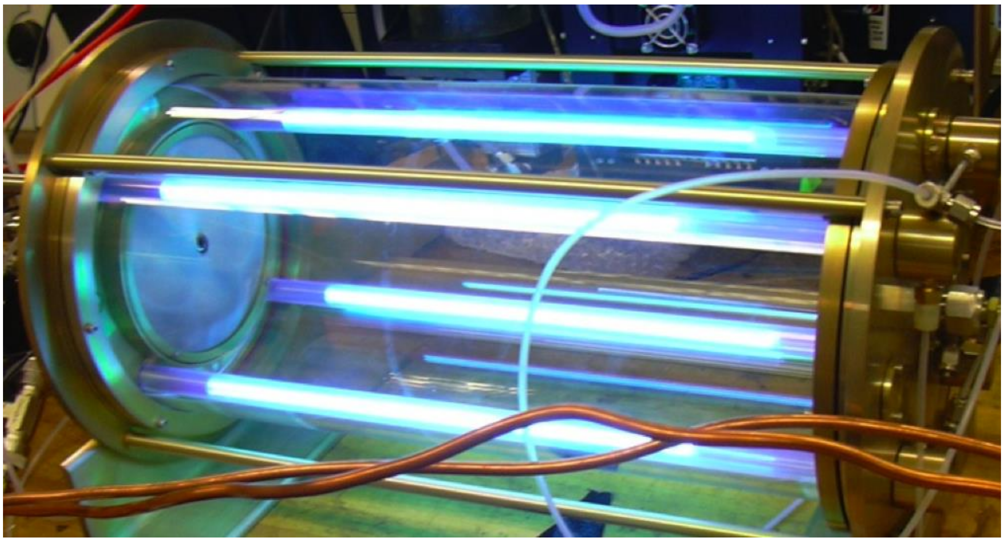

Figure 1. Potential aerosol mass flow reactor. *Photograph by Andrew Lambe at sites.google.com/site/pamwiki/.*

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Non-linear photochemical pathways in laser induced atmospheric aerosol formation

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A well-known and striking effect of laser filaments in humid atmosphere is the creation of new aerosols [1]. We present here the first quantitative measurement of size distribution and chemical composition of laser-induced particles in ambient atmosphere. This atmospheric phenomenon was induced by the Teramobile terawatt mobile laser facility [2] and measured using an Aerosol Mass Spectrometer [3] (AMS) and an optical particle sizer.

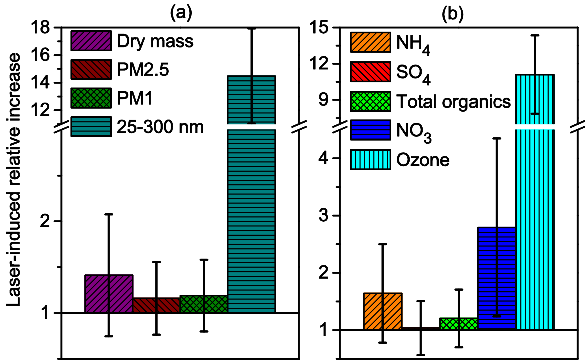

Figure 1. Laser induced increase of (a) the total dry mass detected by the AMS, the aerosol mass detected by the optical sizer (PM1 and PM2.5) and the concentration of nanometric particles, and of (b) mass concentration of different chemical components as well as ozone concentration.

The total mass increase (Figure 1(a)) as well as the size distribution of the laser-condensed mass (Figure 2) confirm that the laser filaments trigger condensation of mass rather than shattering of pre-existing particles by condensation of water and laser-generated compounds. The abundance of ammonium nitrate in the dry mass (Figure 1(b)) allows us to unequivocally define the chemical pathways leading to laser condensation: the photolysis and the ionisation of N_2 and O_2 drive the formation of nitric acid, which then condenses together with ammonia.

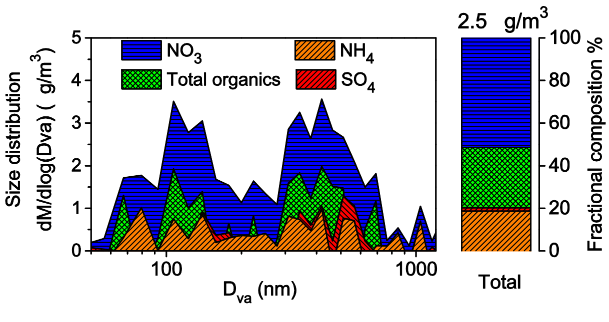

Figure 2. Size distribution of the different components condensed by the laser. Dva is the vacuum aerodynamic diameter.

The presence of organics in the laser-condensed matter is justified by the oxygenation of gaseous organics during their interaction with the strongly oxidative atmosphere near the filaments.
This quantitative experiment allow us to have a better insight and a global understanding of laser-induced condensation in the real atmosphere.

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Filament- Aerosol- Interaction in the Atmosphere

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Above a critical power, laser light propagating in the atmosphere forms filaments which constitute a non-linear, self-guided propagation mode [1, 2]. Filaments lead to self-focusing of the laser light and can extend up to several hundred meters in length [3].

While this unusual mode of propagation is now rather well understood [4], the interaction of the filament with the aerosol system of the atmosphere has only recently been addressed in detail.

In this contribution, an overview is given on the various modes in which filaments interact with the aerosol- and cloud system. These include their effects on new particle formation in the atmosphere [5], on atmospheric water condensation on such particles or preexisting aerosol particles [6, 7], and on the interaction of filaments with cloud droplets [8,9] and atmospheric ice crystals [10].

In all cases, the results of laboratory experiments will be discussed quantitatively and their prospect for new routes for atmospheric remote sensing [11, 12] will be analyzed.

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Thresholds in the climate system

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The inherent non-linearity of the climate system implies that there are numerous thresholds embedded within the system, many of which have not been directly observed in a the past, and a number that may be exceeded at some time in the future, resulting in a range of environmental, economic, and social impacts.

This presentation will thus make a short overview of certain key issues that may influence the course of climate, starting with the Lorenz attractor [1] and looking at some possible bifurcations from the past that have been inferred from glacial and geologic records. We will then look to the future and show that, despite the obvious dependency of climate model solutions on their initial conditions, there are ways of overcoming the predictability of a "noisy" climate through so-called "ensembles" simulations.

Finally, a summary will be provided of some of the driving mechanisms in the planetary environment that could lead to the crossing of a number of (irreversible?) thresholds in coming decades (e.g., [2]).

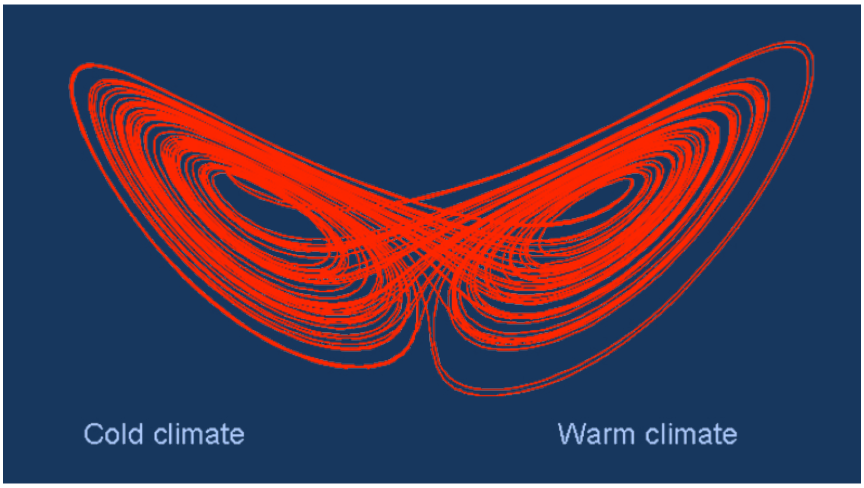

Figure 1. The well-known Lorenz attractor that depicts, for a simple climate model, the apparently-random transitions between a "cold climate" on the left and a "warm climate" to the right. The trajectories in phase space flip back and forth between the two states as a result of varying levels of energy (heat) inputs and distribution within the atmosphere

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Simple tippings or complex transitions?
On the potential for future abrupt climate change

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It has been speculated whether certain elements of the climate system possess so-called tipping points. When driven over such a threshold, climate could suddenly and irreversibly shift toward a different state. The variety of positive feedbacks in the climate system and evidence of abrupt shifts in reconstructions of past climates has motivated climate scientists to investigate the risk of future abrupt change.

The transition of the "Green Sahara" to today's desert several thousand years ago provides a fruitful example of a potential tipping point. Due to the gradual change in the Earth's orbital parameters, northern hemisphere summer insolation decreased, thus weakening the West African summer monsoon and the associated rainfall. It has been discussed to what extent a positive feedback between vegetation and rainfall accelerated the transition from a green to a dry Sahara. Using simple conceptual models we explore how climate variability and land surface heterogeneity can affect the relation between feedback strength and the speed of a transition.

We also discuss the prospects and limitations of so-called "early warning signals": In simple dynamical systems, an increasing relaxation time towards a bifurcation point can lead to increasing autocorrelation and variance. However, such statistical indicators of stability may not be detected in a complex system like the climate due to its spatial complexity. In particular, no early warning occurs at locations that only passively respond to the climate change elsewhere. We show that this fact can be used as an advantage to infer the causal origin of an abrupt change in a climate model.

Also exploring the potential for future abrupt change, we present a catalogue of abrupt shifts in the recent generation of comprehensive Earth system models. We find more than 40 cases of abrupt shifts in the ocean, sea ice, snow cover, permafrost and the terrestrial biosphere, with sea ice cover being the variable most prone to abrupt change. In particular, the models predict that the transition from a seasonally ice-covered to an ice-free Arctic (the loss of Arctic winter sea ice) can occur substantially faster that the loss of summer sea ice. We find that previously proposed feedbacks involving surface albedo and clouds are not responsible for the abrupt sea-ice loss in at least one of the models. Instead, one can explain the phenomenon by geometric reasoning: While summer sea ice is heterogeneous like ice cubes in a glass, the remaining winter ice is uniformly thin, like ice on a lake after a cold night. Once the ocean no longer cools to its freezing temperature in winter, a large ice area is therefore lost.

In synopsis, vegetation in the Sahara, Arctic sea ice, and other potential climate tipping elements all pose similar fundamental questions: What is the balance of the relevant feedbacks? How homogeneous is the system and are there strong spatial connections? What can we learn from the system's variability? Are there natural thresholds which promote or prevent abrupt change? As the underlying processes differ in each case, answers may depend on which potential tipping point is considered. Bridging the gap between the world of tipping point concepts and the world of process understanding will therefore be key to scientific progress.

Modulational instability in forced regimes

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One of the most important formation mechanism for rogue waves is the modulational instability. This is a nonlinear process observed in many different fields of physics where propagating waves nonlinearly interact and exchange energy producing exponential growth of satellites at the expense of the carrier wave. Thus the effect of the modulational instability is to spread energy from an initial narrow bandwidth to a broader one. At leading order, by assuming narrow-banded waves of moderate amplitude that mainly propagate in one direction in a dispersive medium with small amount of dissipation, the propagating waves can be modelled by the nonlinear Schrödinger equation and the modulational instability can be derived within this framework.

Water waves are under the continuous effect of wind which supplies energy and affects the evolution of modulational instability. We describe how, in forced regimes, the modulational instability during the first stage of evolution of deep-water waves develops in different ways depending on the forcing time-scale [1,2]. We show the occurrence of two different regimes that can be described at leading order within the framework of the (forced) nonlinear Schrödinger equation. We illustrate the differences between these two regimes with the help of numerical simulations. We also discuss how the effects of wave-breaking and higher-order nonlinearities compete with wind effects on the evolution of narrow-band modulated waves.

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On the origin of ocean rogue waves

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Rogue waves are highly mysterious and rare phenomena in the ocean. They have been claimed to *come out of nowhere and disappear without a trace*. Exceeding the significant wave height by more than a factor of two, they can cause considerable damage to ships and other maritime structures. Their origin is still highly disputed. Pure linear interference of waves has been discussed as one theory, but could so far not satisfactorily explain observed probabilities for rogue wave emergence. Other models claim a leading role of nonlinearity and resulting formation of breather solitons.

Here we show that rogue wave emergence can in fact be explained by simple linear interference of a small but variable number of elementary waves. We further suggest Grassberger-Procaccia dimensional analysis to extract the effective number of interfering waves immediately from time series of the wave height, measured at one fixed point in the ocean. Further analysis indicates that rogue waves can only form if there is interference of at least 10 waves. Analyzing several wave records in the literature, it is found that even under storm conditions, the rogue wave threshold is often not reached. Analyzing records of the rogue wave that was measured on January 1, 1995 on the Draupner platform, in contrast, indicates a number of at least 12 interfering waves, which clearly exceeds the statistical threshold condition. Going to even larger number of interfering waves, one can see a dramatic increase of the probability for rogue wave formation, much beyond what is predicted by longterm records or parameterless models. In turn, this critical threshold dependence allows for an effective forecast, enabling early-on detection of situations that are prone to rogue wave formation.

With the information on the number of interfering waves, one can develop a simple physical model for rogue wave formation, which identifies a rare phase coincidence of waves as the origin of rogue waves. These individual waves may have been generated in remote parts of the ocean and at different propagation direction. Varying the phase diffusion in this process, one can change the depth of the preceding and trailing characteristic troughs as observed in the Draupner event or generate the characteristic wave pattern of the "three sisters", see Figs. 1(c,d). Flipping the phase at the point of constructive interference, one can also generate the most mysterious rogue wave variant, namely, the rogue hole, see Fig. 1(b).

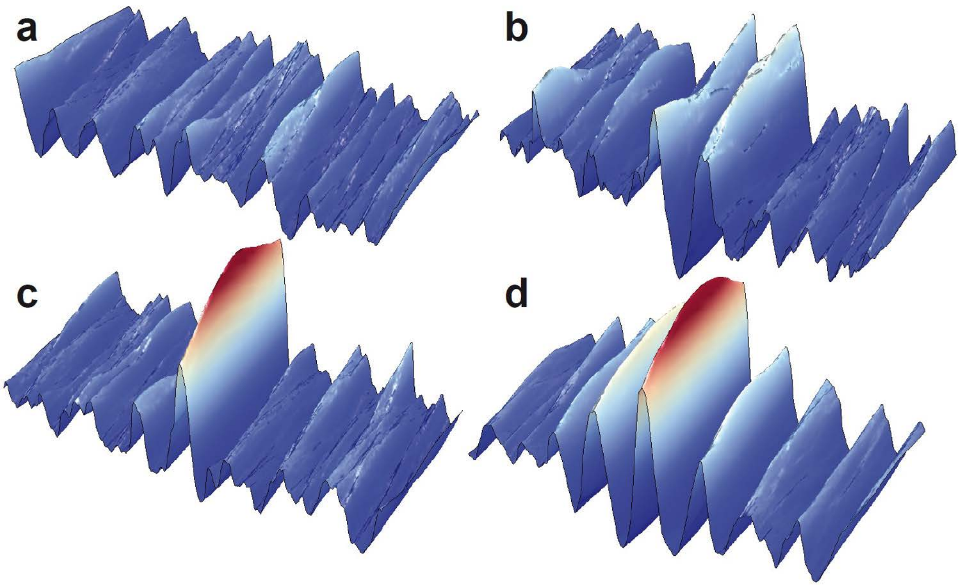

Figure 1. Simulated wave patterns using the phase diffusion model and assuming interference of 20 elementary waves at an angular spread of 50 mrad. (a) Uncorrelated phases. (b) Rogue hole, with all phases set to π at one point along the propagation axis. (c) Rogue wave, same with phases set to 0. (d) "Three sisters", same as (c) but with reduced phase diffusion along the propagation direction.

Our analysis indicates varying winds and atmospheric turbulence as the real origin of these "monsters of the deep". While nonlinearity of the ocean system certainly has a modifying influence on wave formation, rogue waves can emerge in a completely linear fashion as also witnessed by some recent new experiments on their optical counterparts. In conclusion, the answer to the ocean rogue wave mystery does not seem to lie in the depth of the ocean as was commonly believed; instead, this answer seems to be literally blowing in the wind.

Modulational evolution of water-waves at the atmosphere-ocean interface: some similarities with non-linear optics

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The nonlinear Schrodinger equation, who is one of the most significant equations in physics, may model accurately the propagation of nonlinear waves. Some nonlinear waves are known to be unstable to side-band perturbation. This instability, known as the Benjamin-Feir [1] instability or Modulation Instability (MI) in a broader context, can be described by exact pulsating solutions, also referred to as Akhmediev Breathers (ABs). These solutions are of significant importance, since they describe the exact and complete growth and decay cycles of the modulation instability, leading to the Fermi Pasta Ulam [2] (FPU) recurrence.

We report here different theoretical, numerical and experimental evidence on AB dynamics, MI, and FPU recurrence, relative to water waves. We will show some similarities with the propagation of non-linear optic waves leading to breathers, dark and gray solitons and rogue waves.

The experiments were conducted in different wave tanks and air-sea interaction facilities. Our experimental results show a very good agreement with numerical results and emphasize a broad range of possible applications in nonlinear physics [3], [4], [5].

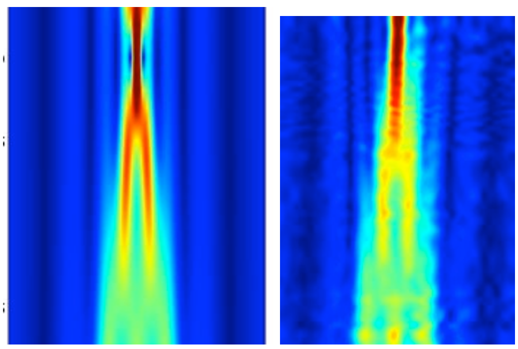

Figure 1 : Theoretical (left) and Experimental (right) simulation of a super rogue water waves

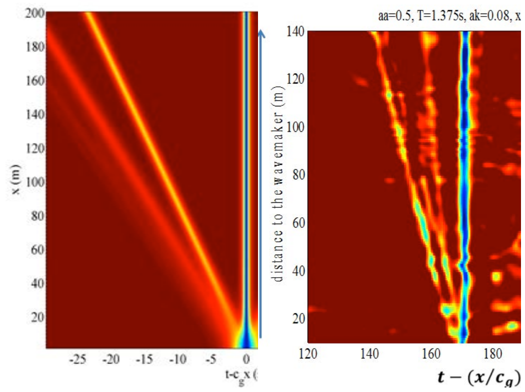

Figure 2 : Theoretical (left) and Experimental (right) simulation of dark soliton water-wave splitting

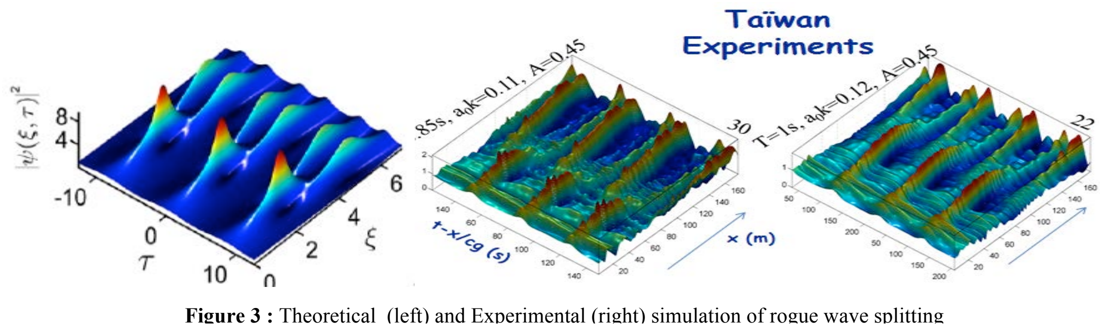

Figure 3 : Theoretical (left) and Experimental (right) simulation of rogue wave splitting

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Laser-induced airflow, water condensation and snow formation in a cloud chamber

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Laser-induced water condensation in the atmosphere might provide a new route to local weather modulation in the future [1]. Generation of intense air current and snow formation have been observed by firing high-repetition femtosecond laser filaments in a diffuse cloud chamber [2-4]. We investigated femtosecond laser-filamentation-induced water condensation and snow formation in a cloud chamber filled with different ambient gases, such as air, argon and helium, respectively. It is found that the mass of laser-filamentation-induced snow in air is much less than that in argon, slightly more than that in helium, while the NO_3^- concentration of the melted snow in argon and helium is significantly lower than that in air. The results indicate that the laser-generated hygroscopic HNO_3 might not be indispensable cloud condensation nuclei (CCN) in the laser-filamentation-induced water condensation and snow formation. It shows that filaments with more laser energy absorbed and more charged-particle generation will induce water condensation and precipitation more efficiently through discussion of the mechanisms of water condensation in three gases.

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Combined effect of UV and NIR beams in laser-induced condensation

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Laser filaments, generated using high power, (>3GW in air), ultrashort, (~50fs) laser pulses, are a self-guided propagation mode, and attract considerable interest due to applications in atmospheric sensing and inducing water condensation. The ionization of the air by filaments initiates chemical reactions, enabling the formation of water aerosol particles in humid, sub-saturated air. We demonstrate the combined effect of a 2.5J near infrared (NIR) femtosecond laser and 250mJ, 10ns, UV beam on laser-induced condensation. The focused 266nm beam produces 6 times more nano-aerosols (25–300nm) than NIR beam with 10 times lower input energy, (Figure 1). Furthermore, launching the UV laser after NIR filaments increases the nano-aerosol production by 20% as compared with the sum of the individual laser contributions, and occurs for delays up to 1 μs. We attribute this to the UV photolysis of ozone, initially created by the NIR pulses. The resulting OH radicals oxidize NO_2 producing more condensable species.

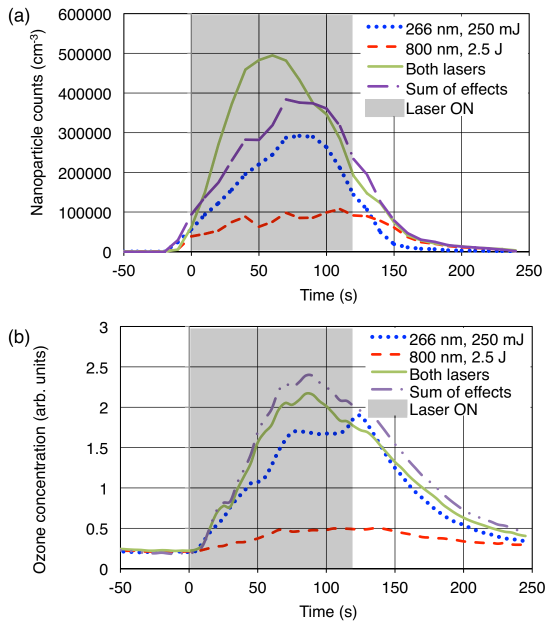

Figure 1. Evolution of the concentration of (a) nanoparticles and (b) ozone under single- or dual NIR-UV-pulse illumination, in the case of a focused UV beam with ≤ 0.1 cm waist. The sum of the individual effects of the NIR and UV pulses is also given for reference.

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Laser guided corona discharges

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Laser based lightning control holds a promising way to solve the problem of the long standing disaster of lightning strikes. The possibility to trigger real-scale lightning in the atmosphere by laser filament [1] has also been demonstrated [2] although there was no direct observation of laser guided lightning strikes. The observation suggested that corona discharges are important and may have been triggered during the interaction between laser filaments and high voltage electric field. The corona discharge plays an important role in the leader initiation process related to lightning. Although laser filament shows great potencial capability to contrl atmospheric lightning, but it is a challenging project due to insufficient understanding of the interaction between laser plasma channel and high voltage electric filed. In this talk, we present our recent progress on direct observation of laser guided corona discharge [3, 4]. The high voltage corona discharge can be guided along laser plasma filament, and enhanced through the interaction with laser filaments. The nonlinear enhancement of fluorescence from the interaction of laser filament and corona discharging electric field was attributed to the more efficient ionization along the laser filament by a spectroscopic analysis of fluorescence, which is the key process for filament guided corona discharge.The fluorescence lifetime of laser filament guided corona discharge was measured to be several microseconds, which is 3 orders of magnitude longer than the fluorescence lifetime of laser filaments. This could be advantageous towards laser assisted leader development in the atmosphere.

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Fundamentals of laser interaction with water droplets

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Laser-induced water condensation (LIC) has been considered in the recent years as a strong candidate for possible precipitation control [1]. Laser filamentation, generated by the dynamic balance between Kerr self-focusing and plasma defocusing of ultrashort laser pulse, is a serious candidate for LIC due to its characteristics of long distance propagation [2], robustness, and capability to travel through fogs and clouds [3], low pressures [4] and even through turbulences [5]. Up to now, few results have been published on the interaction of filaments with water particles and its impact on both the filament and water particles [1, 3, 6]. In the present study, the size distribution of water particles as they interact with a single filament is observed. In addition, a single droplet was interacted with a single filament to measure the energy dissipated during the interaction as well as the changes in particle sizes of a single water droplet after the interaction.

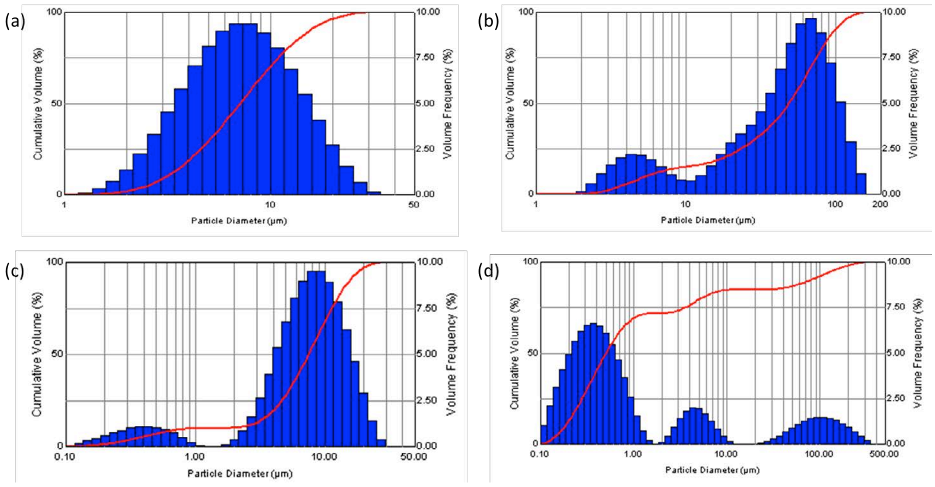

Figure 1 Cumulative volume (red) and volume frequency (blue) of the products of the interaction of a single laser filament with (c) a water spray, and (d) a single droplet interaction with filament (Particle distribution of (a) water spray only, (b) a single droplet used as reference)

Optical shadowgraph images were taken using femtosecond beam to capture and analyze shockwaves of the interaction. Using Sedov-Taylor blast wave equation, the filament energy dissipated in the water droplet was deduced to be ~ 40 µJ [6]. The qualitative measurements of the particle size distribution was made using a Malvern Spraytec aerosol particle analyzer. Figure 1 (a and c) indicate that the water spray has its particle size distribution around 7~8 µm and as small portion of the particles interact with the filament, they are fragmented into sub-micron with its distribution around 400 nm as shown in figure 1 (c). Figure 1 (b and d) indicates that a single droplet of size 70 µm is broken down to around 400 nm as it interacts with the filament. Since it is single droplet interaction, it is clearly shown that the distribution around 70 µm is gone in figure 1 (d). The other two distributions that are visible around 4 µm and 100 µm are noise due to low threshold detection.

The measurement of the energy dissipated during filament-aerosol interaction, as well as the changes in the particle sizes after the interaction are key components to better understand laser-induced water condensation.

This work was funded by the HEL-JTO program on “Fundamentals of Filament Interaction” and the State of Florida.

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Subcycle engineering of laser filamentation in gas by harmonic seeding

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Manipulating at will the propagation dynamics of high power laser pulses is a long-standing dream whose accomplishment would lead to the control of fascinating physical phenomena emerging from laser-matter interaction. During this talk, we will present a significant step towards such a control by manipulating the nonlinear optical response of the gas medium. This is accomplished by shaping an intense laser pulse experiencing filamentation at the subcycle level with a relatively weak (≃1%) third-harmonic radiation. The control results from quantum interference between a single- and a two-color (mixing the fundamental frequency with its third-harmonic) ionization channel [1]. This mechanism, which depends on the relative phase between the two electric fields, is responsible for wide refractive index modifications in relation with significant enhancement or suppression of the ionization rate [Fig. 1(a)]. First, we will present both experimental and numerical results showing the sensitivity, at the microscopic level, of the propagation medium to the presence of an harmonic radiation. Then, we will show that seeding the filament with a weak third harmonic beam can be used to control the natural characteristics of the former [2] or to produce and control an axially modulated plasma channel [3] [Fig. 1(b)]. Finally, we will discuss the impact of the third harmonic radiation naturally self-generated during the filamentation process. We will show that such a radiation can strongly modify the propagation dynamic of a filament and we will discuss the different conditions (in terms of wavelength, pressure, gas…) in which such an effect is expected.

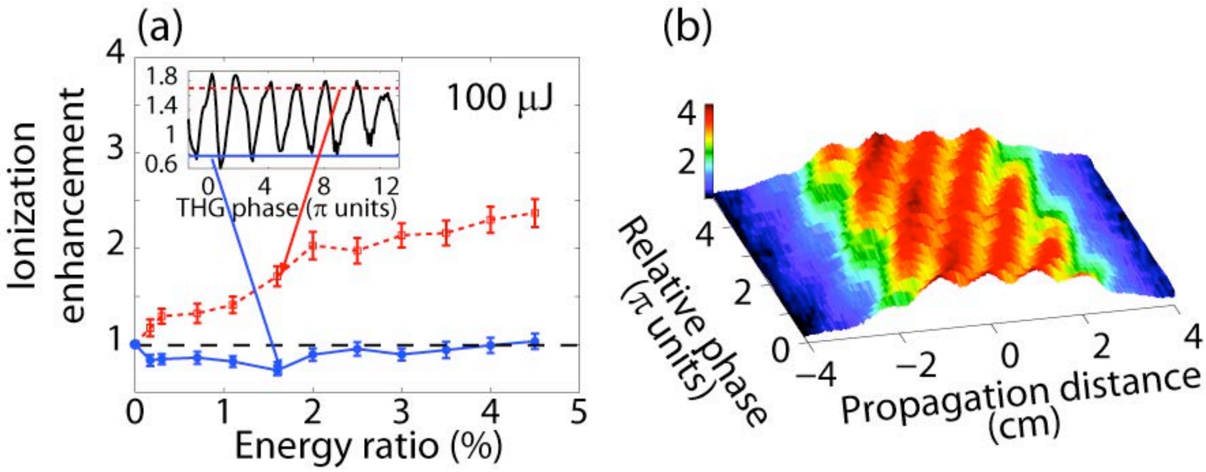

Figure 1. **(a) Modification of the nonlinear optical properties of Argon by the electric field engineering technique.** Ionization yields as a function of the third harmonic energy (expressed in % of the energy of the IR pulse) for an IR energy E_{IR}=100 μJ. The peak intensities I_{IR} (expressed in TW/cm^2) can be approximated by $I_{IR} \simeq 0.5E_{IR}$, where E_{IR} is expressed in μJ. The dash red (solid blue) curves correspond to the relative phase maximizing (minimizing) the ionization yield. The error bars correspond to one standard deviation of the ionization yield modification measured at a given phase. The insets show the experimental ionization yield modification as a function of the relative phase between the two electric fields. **(b) Production and control of an axially modulated plasma channel in the loose focusing regime by harmonic seeding.** Experimental plasma fluorescence along the propagation axis as a function of the relative phase between the fundamental and harmonic fields for a pressure of 1 bar.

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Multiple filamentation as a grid of rigid rotators

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The non-linear Schrodinger equation is an example of an ubiquitous equation that one finds in laser filamentation as well as in the study of trapped ultra-cold atoms forming Bose condensates. Its properties such as integrability in one dimension, finite-time blow-up, or the existence of soliton solutions have been thoroughly studied [1,2] and applied to numerous fields.

In non-linear optics, since the filamentation phenomenon has been experimentally unveiled for the first time, the increasingly available power allowed various groups around the world to develop more and more powerful sources, with laser beams exhibiting waists up to several tenths of centimeters. This achievement led to the observation of peculiar transverse light patterns along the laser path. The intrinsic spatial irregularities of such beams seed many non-linear effects and allow the emergence of light distributions reminiscent of percolation problems or reaction-diffusion systems [3].

Based on these similarities, we showed that the transverse light distribution during a multiple filamentation propagation undergoes a phase transition, that we characterized by a set of seven critical exponents [4]. We further investigated the multiple filamentation phenomenon based on a statistical physics-like approach, and recently showed that one could model this very complex evolution by the means of a simple lattice model [5].

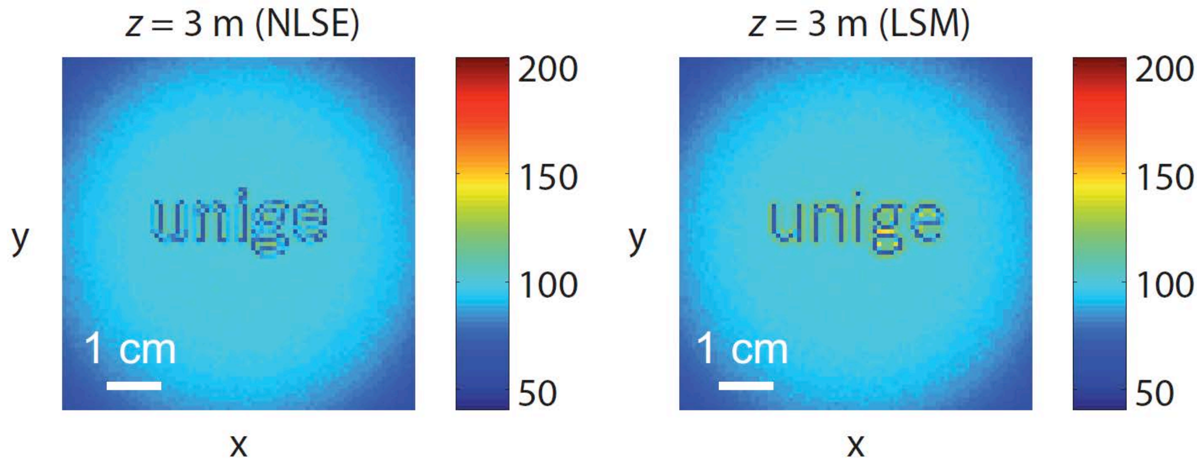

Figure 1. Comparison between the numerically integrated light pattern using standard techniques (Left) and the lattice model result (Right). Qualitative agreement is very good, and shows that the very complex microscopic detail of multiple filamentation can be captured by coarse graining and simple lattice interactions.

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Posters

Time reversibility in laser filamentation

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We investigate the reversibility of laser filamentation [1] a self-sustained, non-linear propagation regime including dissipation and time-retarded effects. We show that even losses related to ionization marginally affect the possibility of reverse propagating ultrashort pulses back to the initial conditions, although they make it prone to finite-distance blow-up susceptible to prevent backward propagation.

Strong deformation of ultrashort laser pulse shapes (Figure 1) is unavoidable when delivering high intensities at remote distances due to nonlinear effects taking place while propagating. Relying on the counter-intuitive reversibility of laser filamentation, we propose to explicitly design laser pulse shapes [2] so that propagation serves as a nonlinear field synthesizer at a remote target location. Such an approach will allow, for instance, coherent control of molecules at a remote distance, in the context of standoff detection of pathogens or explosives.

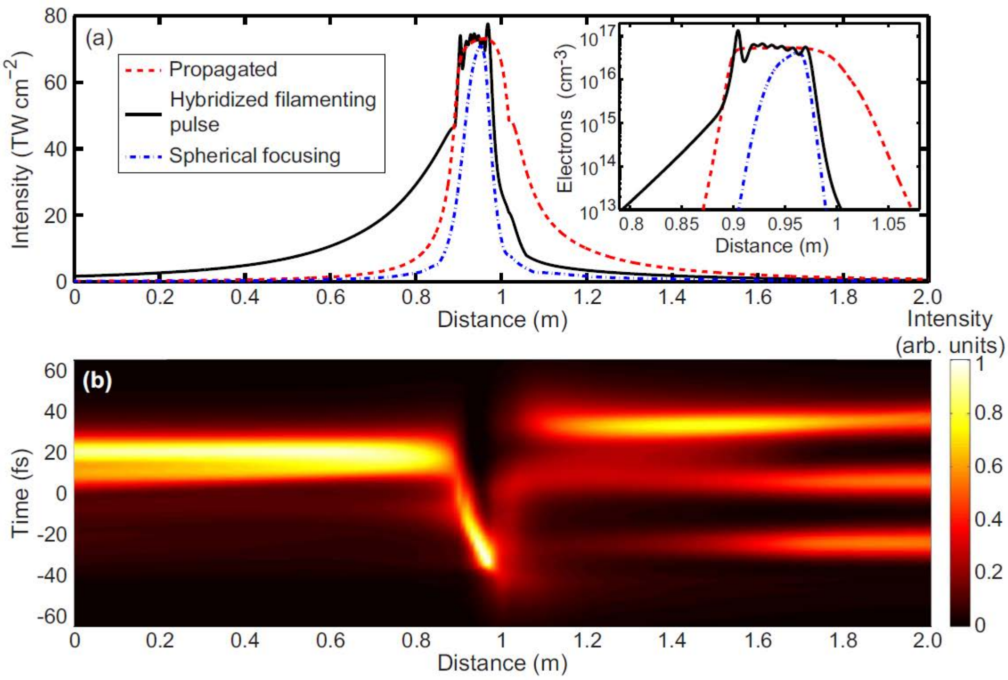

Figure 1. Backpropagation of a target triple pulse. (a) On-axis intensity and electron density. (b) Evolution of the temporal dynamics of the pulse along the propagation distance

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Optimal Femtosecond Pulse Energy Partitioning for Air Ionization

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The control of high-voltage discharges and lightning can be achieved by inducing ionization of air with ultra-short laser pulses [1, 2, 3]. Optimizing the efficiency of these processes require to maximise the ionization yield as well as its lifetime. Sequences of multiple pulses has been shown to be relevant in this purpose [4]. Multiple pulses can increase the ionization yield through different processes [5] by triggering avalanche ionization [6], heating the plasma generated by the first pulse, or photo-detaching electrons from O_2^- ions [7] resulting from the electron attachment on oxygen molecules.

However, most results reported to date investigate the effect of adding one or several subsequent pulses to a reference pulse. As the addition of the subsequent pulses substantially increases the total energy delivered to the system, this can only result in an increase of the observed effect. In the present work, we consider a given laser system delivering a constant total output energy of 6.2 mJ that can be distributed in one to four 450 fs pulses of independent relative intensities and delays between the subpulses. We investigate the effect of partitioning the pulse into a pulse train with arbitrary relative intensities and delays on the ionization yield and the lifetime of the resulting plasma.

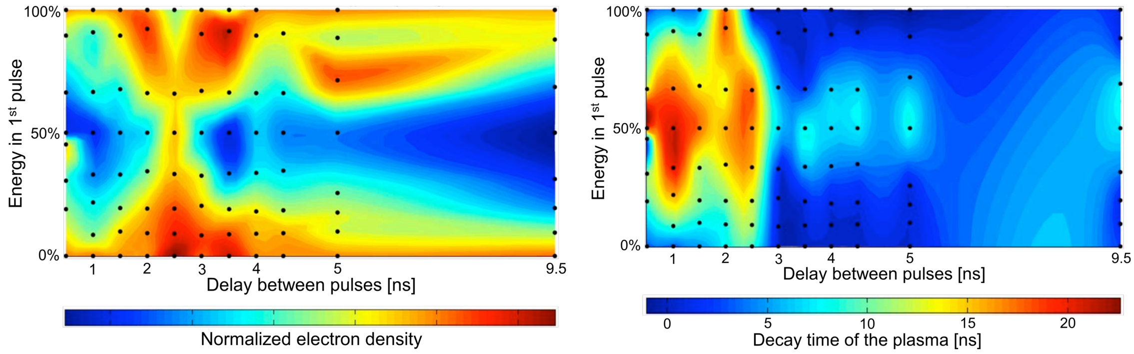

Figure 1. (left) Normalized created electron density and (right) plasma lifetime in air when excited by a double pulse, as a function of the delay and relative intensity between the two pulses.

In contrast to previous expectations, concentrating the energy in one single pulse is the most effective way of creating plasma (Fig. 1 left). A pulse train increases the plasma lifetime by favouring bounces in the plasma creation as soon as each subpulse reaches the energy threshold required to create plasma (Fig. 1 right).

These results provide key information for optimizing laser applications to discharge guiding and lightning triggering.

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The effect of strong wind on Akhmediev breathers

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In hydrodynamics, the nonlinear Schrödinger equation (NLSE) can describe the evolution water waves, under the condition that these are weakly nonlinear and of narrow spectrum. The NLSE can be derived from the more general Navier-Stokes equation using the method of multiple scales (MMS). In the MMS, terms are gathered based on their order in wave steepness *ak*. If one wants to consider the effect of wind on the water waves, a wind-forcing term can be added the NLSE, based on the Miles growth rate: Γ_M. When Γ_M is of the order of the steepness *ak*, this yields what we term a 'strong wind equation'. However, if Γ_M is of the order of ak^2 (i.e. lower), a number of terms become of higher order and as such can be discarded, and the equation is reduced to a 'weak wind equation'.

In current research (e.g.[1]) no distinction is made between the two wind regimes, while we expect that the weak wind model will fail to describe experiments well when the wind becomes too strong (namely of the order of *ak*), because the higher order terms are missing [2]. We address this issue by investigating the evolution of waves under different wind strengths. In particular, we characterize the effect of strong wind the growth rate of the modulational instability and on the downshifting in the spectrum.

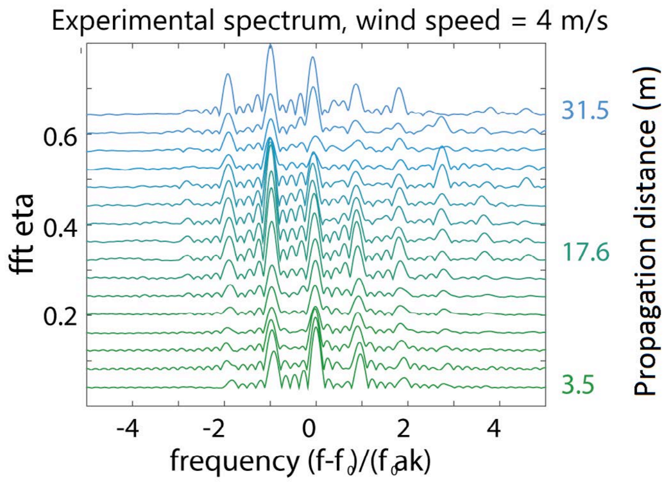

Figure 1. Experimental spectrum obtained at a wind speed U = 4 m/s. The spectrum is vertically offset for each wave gauge. The number on the right denotes the distance from the paddle for the three indicated wave gauges. In the spectrum close to the wave maker (at 3.5 m) one can clearly see the main peak of the carrier wave, and the two satellites that are characteristic for the Akhmediev breather. As the wave propagates through the tank, the dominant peak in the spectrum is shifted to the lower satellite in the spectrum; a clear case of downshifting.

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Spatial and Temporal Model Development for Analysis the Impact of Concentration of Pollutants and Emissions to the Air Quality: A Case Study of Cilegon Industrial Park, Banten Province, Indonesia

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A b s t r a c t

This study aims to develop a spatial and temporal model for emission and pollutant concentration analysis. The model was intended to be developed based on spatial and temporal due to the need in identifying all kinds of pollutants in continues time. The proposed general transformation equation for unsteady flowing is used for detecting the movement of pollutants. The model was implemented using real data in Cilegon Industrial Park, Banten Province, Indonesia. Source of real climate data is from Serang's Meteorology Station Office year 2001-2011 for investigating the emission impact toward the air quality. To examine the validity of the model, the results produced by the model were then compared to the results produced by measurement tool. It can be concluded that the model is acceptable for Emission and Pollutants Concentration Analysis and to forecast Its Impact to Air Quality.

Key words: spatial and temporal model, emission and pollutants

Sensors and Mini Photocatalytic Reactor as a Tool for Measure CO_2 Gas from the Degradation of the Detergent Active Compound

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A b s t r a c t

This study aims to test the performance and feasibility of new tools and methods for analysis of detergent based on the photocatalytic degradation of LAS and ABS, which is a detergent active compound. Testing is done by measuring the CO_2 gas formed from the degradation at every one-hour for five hours of reaction. The results of the determination of analytical parameters are as follows, sensitivity: 0.394 to 0.460, the limit of detection: 0.16 mg/L, accuracy: 0.94% to 12.88% and punctilio: 0.12% to 0.14%, the range of linearity: 0.4 mg/L to 2 mg/L. Results of calibration using standard solutions obtained regression equation y = 1.033 x - 77.713 with R2 = 0.988, indicating that the instrument has been calibrated and fit for use for the analysis of LAS and ABS with concentrations above or equal to 25 mg/L. The test results showed that the developed method is practical, effective and efficient.

Keywords:
CO_2 sensors, photocatalytic, parameter analysis, calibration. LAS and ABS.

Intense Terahertz generation during laser filamentation for application in atmospheric investigations

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Investigation of the atmosphere using electromagnetic waves has been an active area of research over last few decades. In the electromagnetic spectrum, microwaves and lasers have received greater attention, both as probes for analysis of the atmosphere, and also as pumps to strongly perturb the atmosphere. Applications like lightning control and water condensation via laser filamentation, and weather control by microwave induced heating of the atmosphere, have been proposed and tested [1,2]. The elusive Terahertz (THz) radiation band (frequency ~ 0.3-30 THz; wavelength ~ 1000-10 μm), has recently received some attention in the context of atmospheric studies. Large attenuation and scattering of low intensity terahertz frequencies in presence of water vapour, has limited its role to a probe for atmospheric remote sensing [3]. Therefore, generation of intense THz and its subsequent interaction with the atmosphere is an interesting area of research.

Intense THz (integrated energy ~ 10 μJ), has been generated via 2-colour (800 nm + 400 nm) filamentation by terawatt-femtosecond laser in dry air at atmospheric pressure [4]. The primary mechanism of THz production has been attributed to the non-zero drift velocity (and hence a directional current) of the plasma filament electrons, generated by the asymmetric 2-colour laser field. Therefore, THz generation and its spectral characteristics can be controlled by influencing this electron drift current. This is possible by optimizing the laser pulse parameters (pulse width, chirp, pulse front tilt, contrast), and by adjusting the properties of the filamentation media (second order refractive index, ionizability, collisionality). If the laser parameters are fixed, it is expected that the variation in generated THz will carry the signature of the filamentation medium and its immediate surrounding.

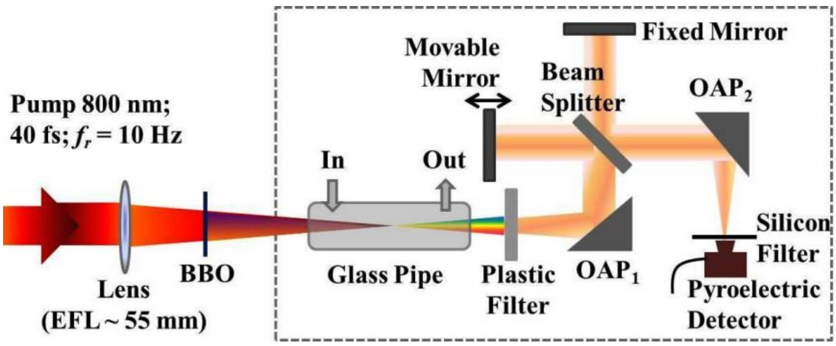

Figure 1. Schematic of the experimental setup, to generate THz by 2-colour filamentation, and measure its spectrum using a field-autocorrelation scheme. OAP → Off Axis Parabola (90°).

In this work, the effect of various gas combinations, on the intensity and spectrum of the 2-colour filament generated THz would be investigated in the laboratory. Figure 1 shows the schematic of the experimental setup for generation of the THz by 2-colour filamentation, and measurement of its spectrum via field-autocorrelation technique using a Michelson interferometer arrangement. An 800 nm pulse of 40 fs duration with peak energy in the range 4 - 40 mJ (maximum repetition rate = 10 Hz) is focused by a convex lens of 55 mm focal length to form a 5 mm long filament. A second harmonic generator crystal (type-I BBO) is placed between the lens and the filament to generate 400 nm second harmonic which is co-focused onto the same filament. The filament is enclosed by a glass pipe with inlet and outlet for circulation of gas mixtures. The generated THz is filtered from the accompanying supercontinuum and remnant laser by high density plastic disc, and collimated by a 90° off-axis parabola (OAP) on to a Michelson interferometer setup for field-autocorrelation measurement. A pyroelectric detector is used for detecting/measuring the THz intensity.

It is expected that the different gas mixtures would significantly alter the THz spectrum due to the near-field interactions, and the scheme may be used for studying gaseous pollutants in the atmosphere.

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Influence of thermal effect on laser-filamentation-induced water condensation and precipitation

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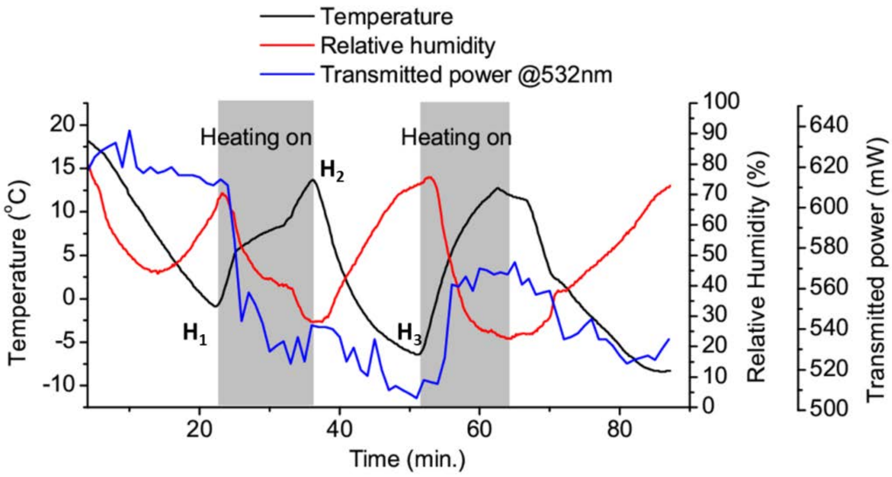

Figure. 1 Development of temperature, relative humidity and transmitted power of probe laser @ 532 nm with time, when an electric heating pipe was introduced inside the chamber.

In our experiment, a 48 W heating pipe, instead of laser filaments (generated by shooting a 1 kHz 8mJ/30fs 800nm laser), was introduced inside the chamber. Experimental results showed that when the electric heating was on it could induce water condensation near the cold plate, which appeared as mist/fog and decreased the transmitted power of a probe laser. When the heating lasted ~15 minutes, it caused a temperature rise of the humid air near the pipe ΔT~40oC (Fig. 1). Then when the electrical heating was off, ice crystals appeared across the whole chamber in 1-2 min. and some of them had grown big enough in size and dropped onto the cold plate directly.

Calculation showed that humid air with large temperature difference following the air flow motion and mixing would generate a super-saturated zone inside the interaction region. Our experimental results demonstrated that, without the generation of any binary CCN, only by introducing a heating source could also trigger the water condensation precipitation processes. That's because the heating pipe induced thermal disturbance, which accelerated the air flow motion inside the chamber. This will enhance the mixing of moist air with a large temperature difference and sustaining a supersaturated state inside. These results are important for the physical understanding of laser-induced water condensation and precipitation processes.

Laser-induced airflow, water condensation and snow formation in a cloud chamber

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In recent years, femtoseconed laser-induced water condensation, generation of snow or ice, and formation of mist or aerosol have been investigated extensively [1-4]. It was shown that self-guided filament could induce water condensation in the atmosphere and snow formation in cloud chambers, which is unlike the traditional method of spraying silver salt particles as seeds into clouds, and thus provides a new tool for remote control of the nucleation processes in clouds. The violent airflow motion would increase the collision probability between the CCN and water vapor/other particles, resulting in water condensation and precipitation with a higher efficiency. In this work, we investigated femtosecond laser-filamentation-induced water condensation and snow formation in a cloud chamber filled respectively with air, argon and helium (800 nm, 1 kHz, 8.2 mJ). It is found that the mass of laser-filamentation-induced snow in air is less than that in argon, slightly more than that in helium, while the NO_3^- concentration of the melted snow in argon and helium is significantly lower than that in air. The results indicate that the laser-generated hygroscopic HNO_3 might not be indispensable cloud condensation nuclei (CCN) in the laser-filamentation-induced water condensation and snow formation.

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