Waterfall-related aerosol inventory

P.Madl[1], P.Kolarž[2], A.Hartl[3], M.Gaisberger[3] and W.Hofmann[1]

[1]University of Salzburg, Material Research and Physics, Hellbrunnerstr. 34 A-5020 Salzburg,

[2]Institute of Physics, Pregrevica 118, RS-11080 Belgrade,

[3]Paracelsus Medical University, Institute for Physiology and Pathophysiology, Strubergasse 21. 11, A-5020 Salzburg,

Corresponding author's e-mail: pierre.madl@sbg.ac.at

Falls (1/4)

Waterfall @ Krimml:

i) *Oberkrimml*, a dead-end valley,

i) glacial water supply,

i) drop-off height: 380m,

i) mean volumetric flow: 5.61 $m^3 \cdot s^{-1}$,

KW, 2010

With their impressive waterfall drop of 380 m the Krimml Waterfalls are the fifth highest waterfalls in the world. With approx. 350,000 visitors each year they are one of the most visited tourist features in Austria. A hiking trail built by the Austrian Alpine Association (OeAV) makes it possible to get very close to this breathtaking nature spectacle, affording sensational views. Enjoy the refreshing mizzle and the impressive power of the water amidst the gorgeous scenery of the Hohe Tauern National Park.

Sources: Krimmler Wasserfaelle:

http://www.wasserfaelle-krimml.at/html_engl/wasserfall_engl.html

Falls (2a/4)

Why does it matter:

Medical studies revealed the beneficial effects of the WFs electro-aerosol:

i) Alleviates chronic **inflammations**, reduces tendency in **asthmatic** attacks and **allergies**;

i) Has a **normalizing effect** on a stressed individuals;

i) Stimulation of the **immuno-biological responses**;


JOANNEUM RESEARCH

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Gesundheitselixier Wasserfall

Gesundheitsfördernde Wirkung von Wasserfällen

von Josef Glanz
17.09.2004
ORF – Modern Times

40.000 Liter Wasser pro Sekunde stürzen tosend und rauschend über die letzte Kante. Und vernebeln mit kleinsten Wassertröpfchen das gesamte Tal. Gerade jene negativen Luftionen, die im Umfeld des Wasserfalls auftreten, und ihre Wirkung auf den Organismus des Menschen sind Gegenstand von Messungen österreichischer Forscher.

Bis zu 70.000 negative Luftionen werden direkt am Wasserfall gemessen, in normaler Raumluft beträgt dieser Wert 300 pro Kubikzentimeter, im Wald bis zu 3.000. Schon vor 200 Jahren nutzte ein Salzburger Arzt, Unsuchalenlich ist das Spritzbade in Krimml vom feinsten Staub bis zum gewaltigen Strom, vom lieblichen Lüftchen bis zum Sturmwind – dies alles hilft gegen Entzündungen, Gemütserregtheit und Empfindeln."

„Schräge Reibe" – Staubige Kurve heißt dieser Platz des Tals, in dem man vom Sprühstaub des Wasserfalls eingenebelt wird.

Univ.-Prof. Dr. Maximilian Moser, JOANNEUM RESEARCH Wei-

Wenn man sich fragt, was für Stoff das ist, dann ist das eigentlich der Stoff aus dem die Sterne sind, es ist nämlich Plasma, geladenen Moleküle, etwas, was sonst nur im Weltraum vorkommt und hier eben durch das fallende Wasser erzeugt wird."

Versuchsaufbau in freier Natur

Wissenschafter des JOANNEUM RESEARCH Weiz samt Probanden auf dem Weg ins gesunde Nass. Versuchsziel: Die Wirkung der negativen Luftionen auf die Testpersonen in Entspannung, bei körperlicher Aktivität und das subjektive Empfinden sollen streng wissenschaftlich untersucht werden. Biologen, Mediziner, Physiker sind am Versuch beteiligt. Das Freiluftlabor ist technisch am letzten Stand – Geräte zur Messung der Körperrhythmen, der Luftionenkonzentration und schließlich die Testpersonen werden vorbereitet.

Elektroden dienen der Messung der Herzfrequenz

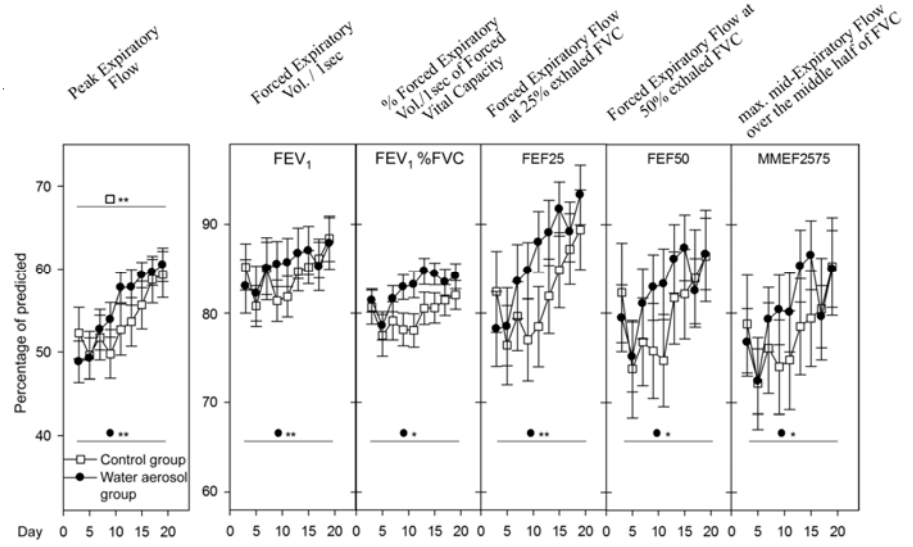
INNOVATION aus TRADITION

Joanneum, 2004

Sources: Modern Times: http://sciencev1.orf.at/science/news/123958

http://www.joanneum.at/fileadmin/user_upload/IND/Beitraege_in_Radio_und_Fernsehen/Fernsehen/Beschreibungen/GW.pdf

Falls (2b/4)



Objective. Ionized water aerosols have been suggested to exert beneficial health effects on pediatric allergic asthma. Their effect was evaluated in a randomized controlled clinical trial as part of a summer asthma camp. Methods. Asthmatic allergic children (n ¼ 54) spent 3 weeks in an alpine asthma camp; half of the group was exposed to water aerosol of an alpine waterfall for 1 hour per day, whereas the other half spent the same time at a "control site". Immunological analysis, lung function testing, and fractional exhaled nitric oxide (FeNO) testing were performed during the stay, and sustaining effects were evaluated 2 months later. Symptom score testing was done over a period of 140 days.

Results. The water aerosol group showed a significant improvement in all lung function parameters, whereas only the peak expiratory flow improved in the control group. All patients showed a significant improvement in symptom score and a significant decrease in FeNO after the camp. Only the water aerosol group exhibited a long-lasting effect on asthma symptoms, lung function, and inflammation in the follow-up examination. Induction of interleukin (IL)-10 and regulatory T (Treg) cells was measured in both groups, with a pronounced increase in the water aerosol group. IL-13 was significantly decreased in both groups, whereas IL-5 and eosinophil cationic protein were decreased only in the water aerosol group.

Conclusions. Our findings confirm the induction of Treg cells and reduction i inflammation by climate therapy. They indicate a synergistic effect of water aerosols resulting in a long-lasting beneficial effect on asthma symptoms, lung function, and airway inflammation.

Table: Measurement of lung function parameters during the asthma camp. For both groups, all parameters indicate improvement in lung functions between day 1 and day 20, with a statistical significance concerning all parameters in the water aerosol group and a significant bettering of PEF in the control group. *p .05, **p .01.

Source: Gaisberger M., Šanovic R., Dobias H, KolarŽ P., Moder A., Thalhammer J., Selmiovic A., Hutteger I., Ritter M., Hartl A. (2012) Effects of Ionized Waterfall Aerosol on Pediatric Allergic Asthma. Journal of Asthma Vol.49(8): 830-838

Intro | Interpretation | Conclusio

Falls (3/4)

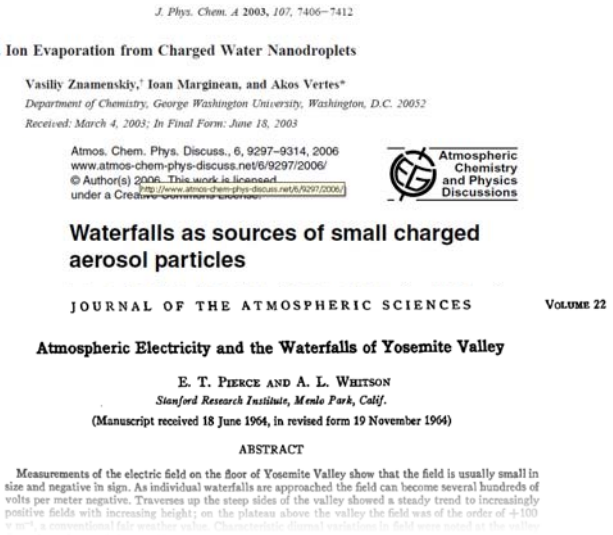
What to expect @ the falls:

i) huge aerosol concentration,
Znamenskiy et al., 2003

i) coupled w/ charge,
Laasko et al., 2006

i) intense static EMF,
Pierce & Withson, 1964

i) obviously high rH and constant Temp.



7406 J. Phys. Chem. A 2003, 107, 7406−7412

Solvated Ion Evaporation from Charged Water Nanodroplets

Vasiliy Znamenskiy,† Ioan Marginean, and Akos Vertes*

Department of Chemistry, George Washington University, Washington, D.C. 20052

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Atmospheric Chemistry and Physics Discussions

Waterfalls as sources of small charged aerosol particles

314 JOURNAL OF THE ATMOSPHERIC SCIENCES VOLUME 22

Atmospheric Electricity and the Waterfalls of Yosemite Valley

E. T. PIERCE AND A. L. WHITSON

Stanford Research Institute, Menlo Park, Calif.

(Manuscript received 18 June 1964, in revised form 19 November 1964)

ABSTRACT

Measurements of the electric field on the floor of Yosemite Valley show that the field is usually small in size and negative in sign. As individual waterfalls are approached the field can become several hundreds of volts per meter negative. Traverses up the steep sides of the valley showed a steady trend to increasingly positive fields with increasing height; on the plateau above the valley the field was of the order of +100

13-09-27 Madl 4

The behavior of electrified droplets in an atmospheric environment and the mechanism of ion formation in electrospray ionization are the subject of continuing debate. Experimental evidence to decide between the various models of ion formation (e.g., ion evaporation, Coulomb explosion, and charge residue model) is not readily available and is especially scarce for nanometer-sized droplets. Even the morphology, the structure, and the dynamics of aqueous nanodroplets containing ionic solutes are poorly understood. Classical molecular dynamics simulations were used to explore the effect of ions on the shape and structure of these droplets ….[1]

In this study, we measured the mobility distributions of cluster and intermediate ions with an ion spectrometer near a waterfall. We observed that the concentration of negative 1.5–10 nm ions was one-hundred fold higher than a reference point 100m away from the waterfall. Also, the concentration of positive intermediate ions was found to be higher than that at the reference point by a factor of ten. This difference was observed only at the smallest sizes; above 10 nm the difference was insignificant.[2]

Measurements of the electric field on the floor of Yosemite Valley show that the field is usually small in size and negative in sign. As individual waterfalls are approached the field can become several hundreds of volts per meter negative. Traverses up the steep sides of the valley showed a steady trend to increasingly positive fields with increasing height; on the plateau above the valley the field was of the order of +100 $V \cdot m^{-1}$, a conventional fair weather value. Characteristic diurnal variations in field were noted at the valley floor. A maximum of about +10 $V \cdot m^{-1}$ was reached near local noon with a minimum of some −60 $V \cdot m^{-1}$ at midnight. The field fluctuated violently at night, but the variations were slow by day. The results can be interpreted in terms of a convective exchange layer the development of which is in phase with solar heating, with negative space charge produced at the waterfalls being entrained into the exchange layer.[3]

The balloelectric ions produced from the waterworks water of high TDS (Total Dissolved Solids) had about the same mobilities as the ions produced from the rainwater of low TDS. This suggests that the balloelectric ions can be considered as singly charged water nanoparticles. By different measurements, the diameter mode of these particles was 2.2–2.7 nm, which is close to the diameter of 2.5 nm of the Chaplin's 280-molecule magic icosahedron superclusters. The measurements can be explained by a hypothesis that the pressure of saturated vapor over the nanoparticle surface is suppressed by a number of magnitudes due to the internal structure of the particles near the size of 2.5 nm. The records of the concentration bursts of balloelectric ions in the atmosphere are formally similar to the records of the nucleation bursts but they cannot be qualified as nucleation bursts because the particles are not growing but shrinking.[4]

Sources:

[1] Znamenskiy V., Marginean I. and Vertes A.: *Solvated Ion Evaporation from Charged Water Nanodroplets*. J. Phys. Chem. A, 107, 7406-7412 (2003).

[2] Laakso L., Hirsikko A., Gronholm T., Kulmala M., Luts A. and Parts T.E.: *Waterfalls as sources of small charged aerosol particles*. Atmos. Chem. Phys. **7**, 2271–2275 (2007).

[3] Pierce E.T. & Whitson A.L.: *Atmospheric Electricity and the Waterfalls of Yosemite Valley*. J. Atmos. Sci., **22**, 314–319 (1965)

[4] Tammet H., Horrak U., and Kulmala M.: *Negatively charged nanoparticles produced by splashing of water*. Atmos. Chem. Phys., 9, 357–367, (2009).

Falls (4/4)

Where to sample @ WF:

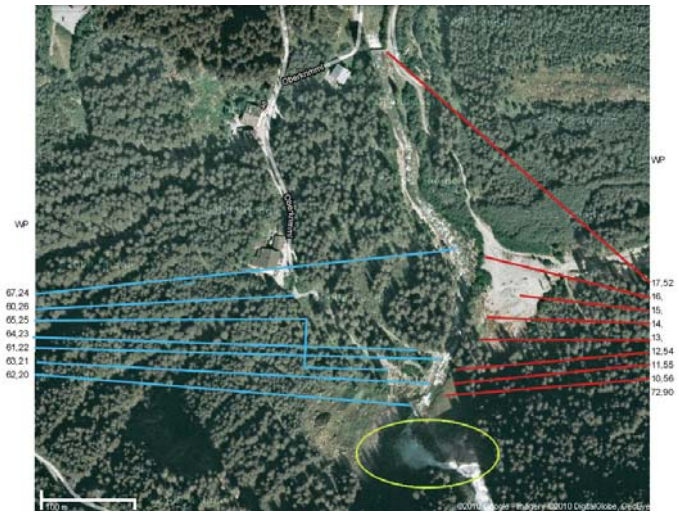
i) *Oberkrimml*, a dead-end valley,

i) glacial water supply,

i) drop-off height: 380m,

i) mean volumetric flow: 5.61 $m^3 \cdot s^{-1}$,

Google maps, 2010

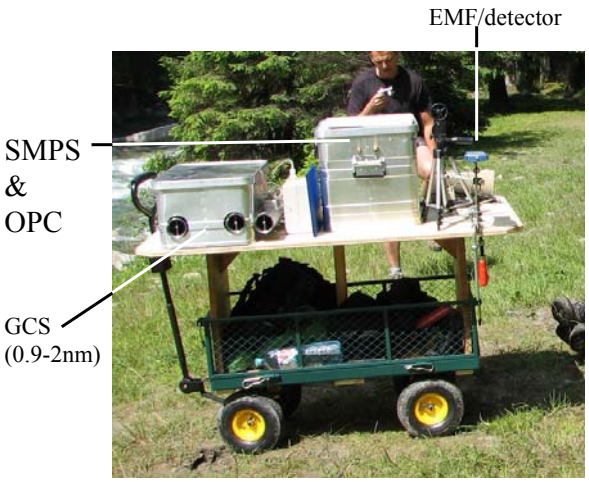


Source: google maps

Equipment (1/5)

Measurement devices:

i) Gerdien Condensers Set (GCS) calibrated to 0.9, 1.5 & 2nm for both positive & negative ions.
i) Scanning Mobility Particle Sizer (SMPS) covering a range of 5.5-350nm.
i) Optical Particle Counter (OPC) w/ a range 0.3-20µm.
i) EMF-detector (SA) for fields in the range of 0-30MHz.
i) GPS, T & rH data logger.



The current study investigated the distributions of ionic-clusters and aerosols originating from waterfalls. The 10 day measurement campaign was performed with three portable Gerdien condensers (air-ion detectors) to monitor air-ion concentrations [1] and a Scanning Mobility Particle sizer (SMPS), along with an optical particle counter (OPC) to determine the size distribution of aerosols. The size spectra covered in each measurement ranged from 0.9 to 350nm for the negative ion concentration. Determination of negative charges using the SMPS covered the full range, whereas the positive complement was restricted to a size window of 0.9 to 2nm and was determined by the detection principle of the SMPS. Using the fully-fitted SMPS (with the neutralizer attached to the DMA) made it possible to monitor aerosol distributions in the size window ranging from 5.5 to 350nm. In combination with the OPC, it was possible to extend the upper threshold up to 2µm.

The investigation revealed a distinct aerosol distribution in proximity to the falls along with a soaring concentration of negative ions in the lowest size range below 10 nm. As expected, off-site control measurements used to monitor background ion- and particle concentrations prompted significantly different signatures. The increased concentration of negative intermediate ions is assumed to be due to the so-called waterfall effect [2], in which auto-ionization due to friction, fragmentation and charge-separation mechanisms cause free charges inside water droplets. Fluctuation in charges and their mobility yield free ions when a droplet collides with an obstacle. Aerosol spectra on the other hand showed a distinct "wash-out-effect" of otherwise specific aerosol distribution in the absence of a waterfall, whereas aerosol concentrations – especially in the lower size range below 100nm – are elevated as condensation and agglomeration effects are suppressed due to the cooler microclimatic conditions near the falls.

Sources:

[1] Kolarz P.M., Filipovi D.M., Marinkovi B.P., "*Daily variations of indoor air-ion and radon concentrations*", Applied Radiation and Isotopes **67**, 2062–2067 (2009)

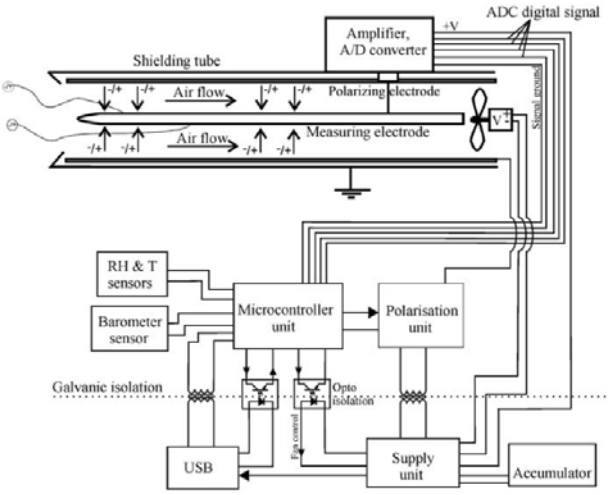
[2] Laakso L., Hirsikko A., Gronholm T., Kulmala M., Luts A. and Parts T.E. "*Waterfalls as sources of small charged aerosol particles*", Atmos. Chem. Phys. **7**, 2271–2275 (2007)

Equipment (2/5)

Measurement principles:

i) Gerdien Condensers Set (**GCS**).
i) Scanning Mobility Particle Sizer (SMPS).
i) Optical Particle Counter (OPC).
i) EMF-detector (SA).
i) GPS, T & rH data logger.

Kolarž, 2009

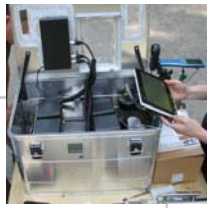


The aspirated Gerdien condenser (CDI-06) is a widely utilized instrument for the air-ion concentrations and mobility measurements. It is a fully automated portable instrument with ability to alternatively measure concentrations of positive and negative airions, temperature (T), pressure (P) and relative humidity (RH).

Sensor part of the CDI-06 consists of three cylindrical and coaxially arranged electrodes, i.e., measuring (central), polarizing and shielding electrode. The space between the electrodes is ventilated by a fan. In the inter-electrode space air-ions of desired polarity and mobility are forced by electric field to deliver their charge to the measuring electrode. The charge collected on this electrode is measured by an electrometer, recalculated and represented as concentration of air-ions in units of cm^3 with desired time resolution and averaging. The mobility of the ions is determined by the applied polarizing voltage and air-flow velocity. Polarizing voltage is set in a way that only small airions are collected on the central electrode. Larger ions, according to their kinetic energy, could not be deflected and they pass through electrodes. Air-flow (Q) is $8.7103 m^3/s$, which is relatively high for this kind of instrument. This provides lower inherent statistical and instrument (signal amplification) uncertainty. The most important feature of CDI-06 is that the ion generated current signal is amplified, digitalized and zeroed. Zeroing of the system is performed periodically in order to compensate the noise sources induced by the changes of T, RH, external electromagnetic waves and high voltage peaks induced by polarity change or fan stopping/starting. Zeroing indicates that the signal measured during the zero conductivity is subtracted from further measurements until next zeroing. Zero conductivity regimes imply that the polarizing voltage and the fan are off, and under these circumstances, measuring electrode collects only ions that are led by Brownian motion, and output signal should be about a few ions/cm3. Digitalization of CDI output signal enables programmed autozeroing and automatic long term measurements without the presence of human operator. Five identical copies of CDI-06 were made so that they all could be mutually compared and tested, so any kind of systematic error due to instrumentation is avoided. The sources of measuring uncertainties of CDI-06 in indoor conditions are components of the systematic uncertainty arising from air-flow uncertainty 3%, input calibration error 1.4%, temperature drift of feedback resistor (50 ppm/1C, i.e., 0.2%), gain error of operational amplifier (30 ppm/1C, 0.12%) and voltage reference error (50 ppm/1C, 0.2%). Leakage currents of the amplifier (within 2 fA) and within electrodes are compensated by the zeroing system. Overall uncertainty of the CDI-06 is in the range of 5% if the ambient humidity is below 80%. Measuring uncertainty in outdoor conditions is mostly subjected to intensity and direction of wind and high relative humidity, so it can be evaluated up to 30%.

Sources: Kolarz P.M., Filipovic D.M., Marinkovic B.P.: *Daily variations of indoor air-ion and radon concentrations*. Applied Radiation and Isotopes, 67, 2062–2067 (2009).

Equipment (3/5)



Measurement principles:

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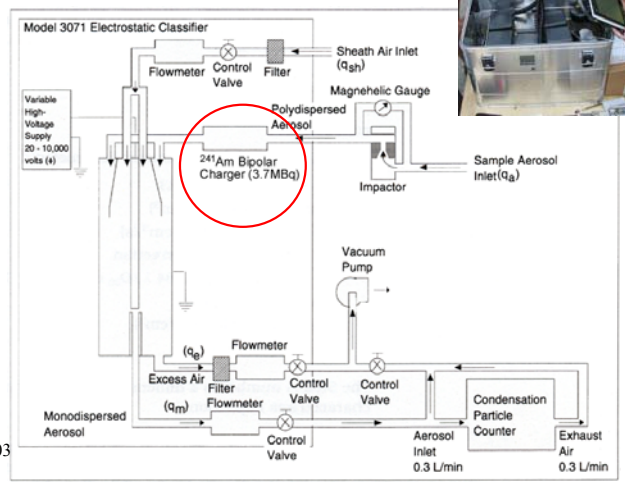

Madl, 2003

The Scanning Mobility Particle Sizer system (SMPS Grimm model 5400) is capable of measuring the size distribution of sub-micrometer (5nm to 1μm) aerosols using an electrical mobility separation technique. T he particles are classified with an Electrostatic Classifier (DMA) and their concentrations are measured with a Condensation Particle Counter (CPC). The SMPS is an automated system that is operated via an attached computer. By modifying the parameter settings of the SMPS software, it is possible to control the individual instruments according to the experimental requirements.

DMA: The instrument consists of three major components: an impactor, an aerosol neutralizer* and a differential mobility analyser. As illustrated this is achieved by grounding the outer cylinder and applying a positive voltage to the centre rod. For a given voltage, charged particles with mobilities greater than a certain amount will migrate to the oppositely charged cylinders as the aerosol gas stream pushes them through. Uncharged particles pass through unaffected. The laminar flowing aerosol is fed into the classifier. A sheath of particle free air surrounds the central rod. At the beginning of a scan, the inner cylinder is maintained at the same potential as the outer cylinder; i.e. grounded. Once the scanning process is started, the center rod voltage gradually increases in voltage. As this process is controlled by the microcomputer, recordings of the concentration measurement are correlated with the aerosol size distribution due to the response function of the DMA. This potential generates a radial electric field with respect to the classifier wall. The particles entering the column are separated according to their charge. Particles that are positively charged are drawn towards the centred electrode, while negatively charged ones will be pushed away, precipitate and neutralize at the grounded outer cylinder. These particles no longer play a role in the measurement. Only particles that have a narrow band of electrical mobility have trajectories that enable them to cross the sheath-air flow to be sucked into the inlet slit of the central rod. Therefore, it is possible to calculate the concentration within that size range which left the DMA through the monodisperse aerosol outlet.

(*) the **aerosol neutralizer** crucially interferes in the data acquisition of ions – therefore has to be removed when sampling ions and needs to be refitted when measuring aerosols!

Sources: Madl P.: *Instrumental development and application of a thermodenuder*. Master thesis submitted at the University of Salzburg and Queensland University of Technology (2003). http://biophysics.sbg.ac.at/exotica/thesis-piero.pdf

Equipment (4/5)

Measurement principles:

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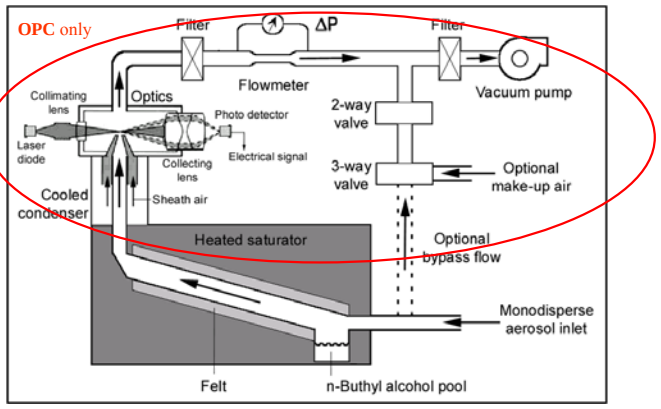

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CPC: The CPC is capable of grouping particles into size classes in the range of 5-1080nm. It is widely used for the detection of the number concentration of sub-micrometer particles. A continuos-flow CPC has a wide dynamic range ($<1 \cdot E^{-5}$ to $1 \cdot E^{7}$ particles/cm^3). A CPC uses a monochromatic light of a single frequency (usually 780nm laser) by focusing on the passing train of particles to detect them. Since such a wavelength falls short to detect particles in the smaller size range (<700nm), the sized aerosols from the EC must undergo condensation to increase in size. CPCs saturate an aerosol by alcohol vapour and then to cool it in a supersaturated environment (condenser) to achieve rapid growth of sub-micrometer particles under steady flow conditions. Before going through the working principles of a CPC, briefly some theoretical aspects of the physical principles employed within this counter. As shown, the CPC consists of a saturator, condenser, and particle detector. As the monodisperse, unipolar and positively charged particle train enters the CPC, it is saturated with n-Butyl alcohol vapour as it passes over a heated pool of alcohol. The residence time is such that the aerosol will be saturated with the working fluid at a set temperature of 35°C (308 K). Then, the vapour-saturated aerosol flows into the 10°C (283 K) cold condenser, where it is cooled by thermal diffusion.

OPC: The optical system of a CPC is commonly known as an optical particle counter (OPC) in which the aerosol enters a nozzle (measuring 10mm by 2mm) and flows through a focused laser beam as a thin stream surrounded by sheath air. Ideally, only one particle at a time is illuminated and to scatter light to the photo detector, which converts it to an electrical signal. The electronic pulse height (area under the curve) is used to interpret the pulse and forward a count to the proper size channel where the total counts in each size range (bin) are accumulated.

Together with the DMA, the SMPS-software combines the information of centre-rod voltage and particle concentration to calculate and plot the size distribution.

Sources: Madl P.: *Instrumental development and application of a thermodenuder*. Master thesis submitted at the University of Salzburg and Queensland University of Technology (2003). http://biophysics.sbg.ac.at/exotica/thesis-piero.pdf

Equipment (5/5)

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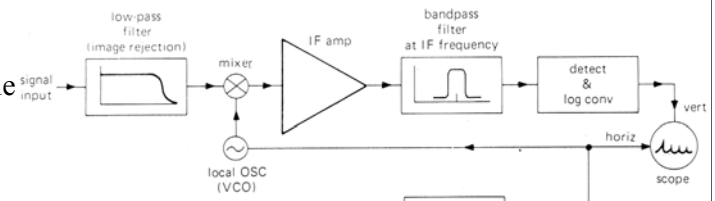


Spectran, online

A spectrum analyzer (SA) or spectral analyzer is a device used to examine the spectral composition of some electrical, acoustic, or optical waveform. There are analog and digital spectrum analyzers:

* An analog SA uses either a variable band-pass filter whose mid-frequency is automatically tuned (shifted, swept) through the range of frequencies of which the spectrum is to be measured or a superheterodyne receiver where the local oscillator is swept through a range of frequencies.

* A digital SA computes the discrete Fourier transform (DFT), a mathematical process that transforms a waveform into the components of its frequency spectrum.

Some SAs (such as "real-time spectrum analyzers") use a hybrid technique where the incoming signal is first down-converted to a lower frequency using superheterodyne techniques and then analyzed using fast fourier transformation (FFT) techniques.

Usually, a SA displays a power spectrum over a given frequency range, changing the display as the properties of the signal change. There is a trade-off between how quickly the display can be updated and the frequency resolution, which is for example relevant for distinguishing frequency components that are close together. With a digital SA, the frequency resolution is $\Delta\nu=1/T$, the inverse of the time T over which the waveform is measured and Fourier transformed (according to Uncertainty principle). With an analog SA, it is dependent on the bandwidth setting of the bandpass filter. However, an analog spectrum analyzer will not produce meaningful results if the filter bandwidth (in Hz) is smaller than the square root of the sweep speed (in Hz/s), which means that an analog spectrum analyzer can never beat a digital one in terms of frequency resolution for a given acquisition time. Choosing a wider bandpass filter will improve the signal-to-noise ratio at the expense of a decreased frequency resolution.

With Fourier transform analysis in a digital spectrum analyzer, it is necessary to sample the input signal with a sampling frequency νs that is at least twice the highest frequency that is present in the signal, due to the Nyquist limit. A Fourier transform will then produce a spectrum containing all frequencies from zero to $\nu s/2$. This can place considerable demands on the required analog-to-digital converter and processing power for the Fourier transform. Often, one is only interested in a narrow frequency range, for example between 88 and 108 MHz, which would require at least a sampling frequency of 216 MHz, not counting the low-pass anti-aliasing filter. In such cases, it can be more economic to first use a superheterodyne receiver to transform the signal to a lower range, such as 8 to 28 MHz, and then sample the signal at 56 MHz. This is how an analog-digital-hybrid spectrum analyzer works.

For use with very weak signals, a pre-amplifier can be used, although harmonic and intermodulation distortion may lead to the creation of new frequency components that were not present in the original signal. A new method, without using a high local oscillator (LO) (that usually produces a high-frequency signal close to the signal) is used on the latest analyzer generation like Aaronia´s Spectran series. The advantage of this new method is a very low noise floor near the physical thermal noise limit of -174 dBm/Hz.

Sources: Wikipedia, http://en.wikipedia.org/wiki/Spectrum_analyzer

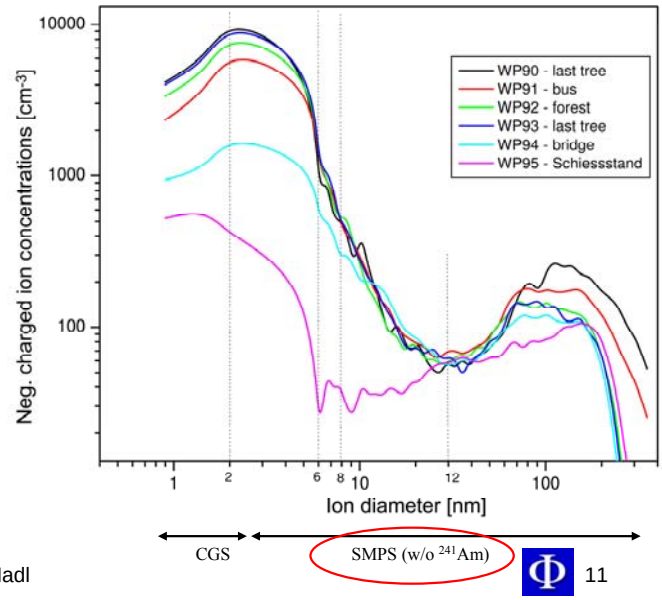
Ions (1a/4)

GCS-/SMPS-results (0.9-350nm):

i) Inhalable fraction of;
i) **neg. charged** aerosols (relevant for later on);
i) *Lenard*-effect (spray electrification, 1892);

the further away from the WF, the more dominant the peak shifts towards smaller ion sizes ….

data Kolarž et al., 2011



Lenard effect - also called spray electrification, waterfall effect - is the separation of electric charges accompanying the aerodynamic breakup of water drops, first studied systematically by the German physicist P. Lenard (1892).

Experiments have shown that the degree of charge separation in spray processes depends upon the drop temperature, presence of dissolved impurities, speed of the impinging air blast, and contact with foreign surfaces. The largest fragments of the broken drops are observed to carry positive charges and the fine spray of drops carried off in the impinging air current carries a net negative charge. Distilled water drops of 4mm diameter, broken after a 5cm free fall into an updraft of 1m/s, were found by Chapman (1953) to yield about 1E−10 C of separated charge per drop. The Lenard effect was incorporated by Simpson (1927) into his breaking-drop theory of thunderstorm charge generation, but many critical details are but poorly understood.

The plot above was generated by combining the values of the CGS and SMPS-instruments. However, in order to measure ions with the **SMPS, the instrument MUST be operated without the radioactive discharging device** attached to the instrument.

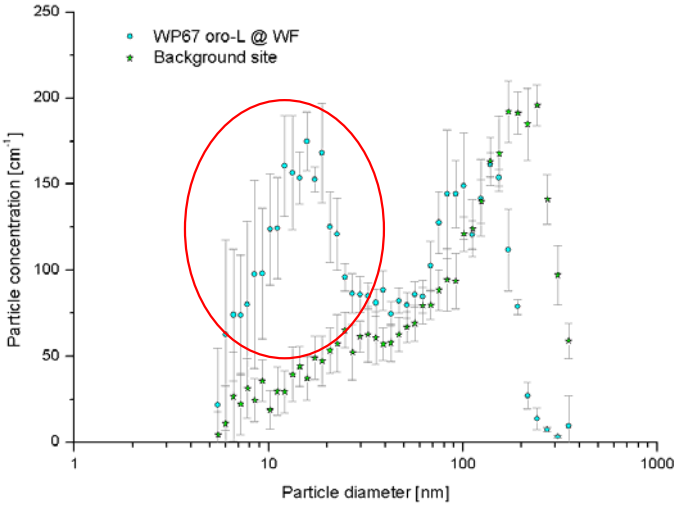
Source: http://amsglossary.allenpress.com/glossary/search?id=lenard-effect1
Chapman, S., 1953: Thunderstorm Electricity, Byers, H. R., ed., 207–213
Simpson, G. C., 1927: Mechanism of a thunderstorm. Proc. Roy. Soc. A, 114, 376–401.
Lenard, P., 1892: Über die Elektrizität der Wasserfälle. Ann. Phys., Lpz, 46, 584–636

Nano-Aerosols (2a/4)

SMPS-results (5.5-350nm):

i) inhalable fraction;
i) due to **forced neutralization** of the nano-aerosols (w/ ^{241}Am), ions are no longer visible
(peak aerosol concentration is 2 orders of magnitude lower than that of ions).

data Madl



Aerosol Discharger @ SMPS: As the SMPS classifies an aerosol by means of an applied electrical field, it is important that the aerosol entering the device has the same net charge; i.e. either one positive or one negative charge.

Thus the polydisperse aerosol entering the DMA, is passed over an 85Kr bipolar β-emitter, (discharger or neutralizer), that exposes the aerosol particles to high concentrations of bipolarions which alters the charge distribution to Boltzmann's equilibrium. In that process, the particles and ions undergo frequent collisions due to the random thermal motion of the ions. Within milliseconds, the particles reach a state of equilibrium, in which the particles carry a bipolar charge distribution; whereas in the free atmosphere, cosmic radiation would take as much as 30mins to achieve. As the single charge condition is an idealized assumption, one has to keep in mind that particles can gain more than one charge. The Boltzmann charge distribution assumes that the distribution is symmetrical around zero; that is, the fraction of particles with *n* positive charges equals the fraction with *n*-negative charges. Thus, when particles are exposed to a gaseous medium containing bipolar ions, the particles and ions will undergo frequent collisions due to random thermal (Brownian) motion. Thus, in time, an equilibrium state is attained in which the particles carry a bipolar charge distribution.

However, usage of the discharger comes with a price: in this particular application, **we loose the characteristic negative charge of the ions originating from the waterfall (compare ion- with aerosol-concentration in a given size class - I.e. peak aerosol concentration is about 2 orders of magnitude lower than that of the ions)**.

The aerosol spectrum obtained with the SMPS peaks at around 200nm …. This is quite consistent with the OPC data (see slide 13).

Source: Madl P. (2003) Application of a Thermodenuder.
http://biophysics.sbg.ac.at/exotica/thesis-piero.pdf

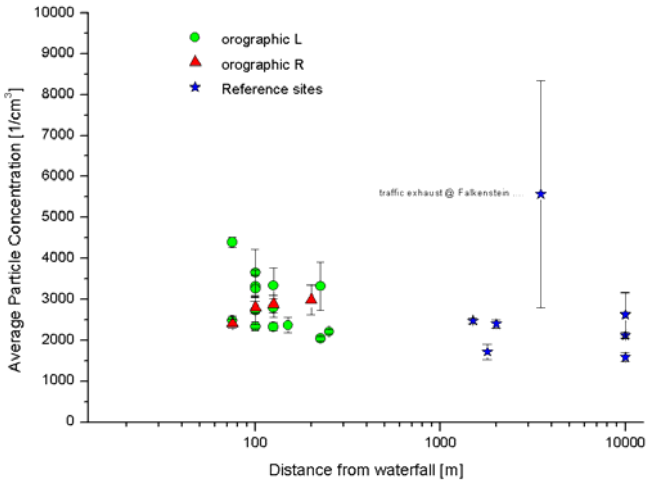
Nano-Aerosols (2b/4)

SMPS-results (5.5-350nm):

i) due to **forced neutralization** of nano-aerosols, ions are no longer visible

i) difference b/w WF nano-aerosol fraction & BCKGRD becomes less significant.

data Madl



Due to the neutralization of the aerosole species, the charge component is stripped off leaving the bulk aerosol which is hardly larger than the background concentration – even with distance.

Nano-Aerosols (2c/4)

SMPS-results (5.5-350nm):

Atmos. Chem. Phys., 12, 3687–3697, 2012
www.atmos-chem-phys.net/12/3687/2012/
doi:10.5194/acp-12-3687-2012

Atmospheric Chemistry and Physics

Characterization of ions at Alpine waterfalls

P. Kolarž[1,*], M. Gaisberger[2,*], P. Madl[3], W. Hofmann[3], M. Ritter[2], and A. Hartl[2]

[1]Institute of Physics, University of Belgrade, Pregrevica 118, 11080 Belgrade, Serbia
[2]Institute of Physiology and Pathophysiology, Paracelsus Medical University, Strubergasse 21, 5020 Salzburg, Austria
[3]Department of Materials Research and Physics, Division of Physics and Biophysics, University of Salzburg, Hellbrunner Str.

Abstract. During a three-year field campaign of measuring waterfall generated ions, we monitored five different waterfalls in the Austrian Alps. Most measurements were performed at the Krimml waterfall (Salzburg, Austria), which is the biggest waterfall in Europe, and the Gartl waterfall (Moelltal, Austria). We characterized spatial, time and size distributions of waterfall-generated ions under the influence of surrounding topography. The smallest ions with boundary diameters of 0.9, 1.5 and 2 nm, were measured with a cylindrical air ion detector (CDI-06), while ion sizes from 5.5 to 350 nm were measured using a modified Grimm SMPS aerosol spectrometer. High negative ion concentration gradients are detected in the vicinity of the waterfalls, whereas the increase of positive ions was only moderate. Ions in the nano range were the most abundant at 2 nm, and at 120 nm in the sub-micrometer range.

Source: Kolarz P., Gaisberger M., Madl P., Hofmann W., Ritter M., Hartl A., (2011) Characterization of ions at Alpine waterfalls. Atmos. Chem. Phys., Vol.12: 3687–3697

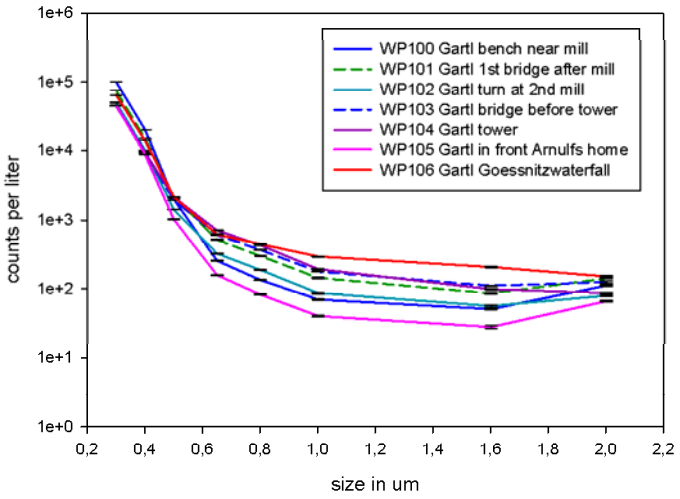
Micro-Aerosols (3a/4)

OPC-results (1-2µm):

i) micro-aerosols originating from the WF deviate at around 1µm-range

i) **significant difference** as no forced neutralization of aerosol takes place (OPC works w/o radioactive discharger)

data Hartl



Following the observation of the SMPS data, the accumulation mode peak at around 200nm is also observed in the OPC data. This common peak seems to be a characteristic fingerprint region of the valley in Krimml, as it was observed both in the waterfall scans as well as in the background measurement sites.

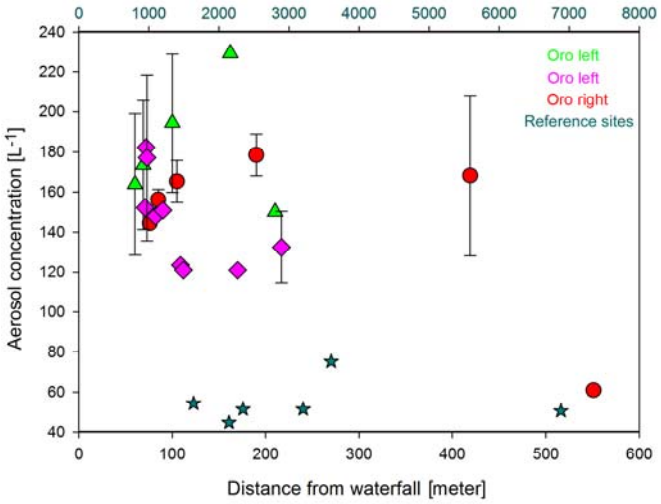
However, when comparing this spectrum with the SMPS-data (aerosol concentration below 200nm), the difference in aerosol concentration above this characteristic 200nm peak at the waterfall and further away from it shows a significant difference, Since the OPC detection principle does not employ a neutralizer the aerosol is not subjected to any charge-alteration. The differences between remote and waterfall-sites are at least one order of magnitude.

Micro-Aerosols (3b/4)

OPC-results (1-2µm):

i) micro-aerosols originating from the WF deviate at around 1µm-range

i) **significant difference** as no forced neutrali-zation of aerosol takes place (OPC works w/o radioactive discharger)



data Hartl

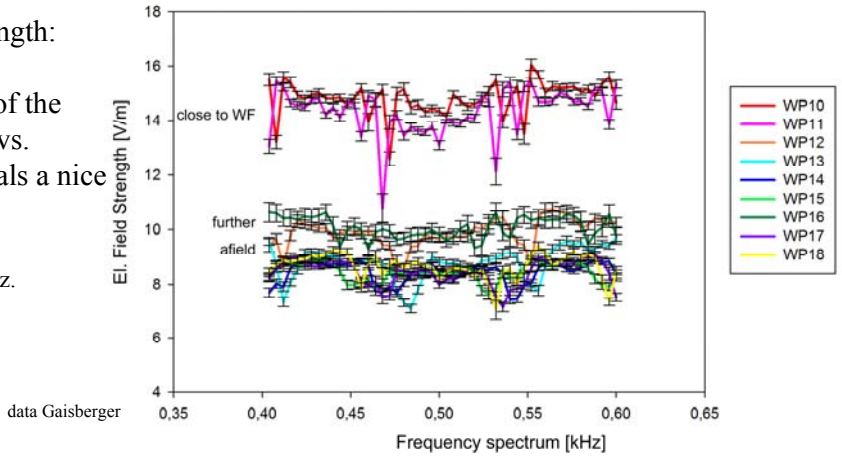
The differences between sites close and further afield from the waterfall are much more prominent than in the SMPS-data.

EMF (4/4)

EMF-field strength:

i) fluctuations of the electric field vs. distance reveals a nice gradient.

Resolution 0.03kHz.



data Gaisberger

The measurements made on the valley floor closed to the waterfall not only revealed the negative fields, but moreover a spectral fluctuation that also extended into the LF-range (here 350-650Hz). Yet this observation decreased with distance from the waterfall, only to flatten out and attain again the characteristic field intensity observed over the remainder of the valley; i.e. some hundreds of volts per meter.

Comment:

WP10 = oro right wo die Kinder exponiert wurden

WP11 = oro right am Waldrand

WP 17/18 = kneipp anlage

Dann in steigender Entfernung weitere waypoints und Werte

Zeigt recht eindrucksvoll die el Feldstärke am Wasserfall …

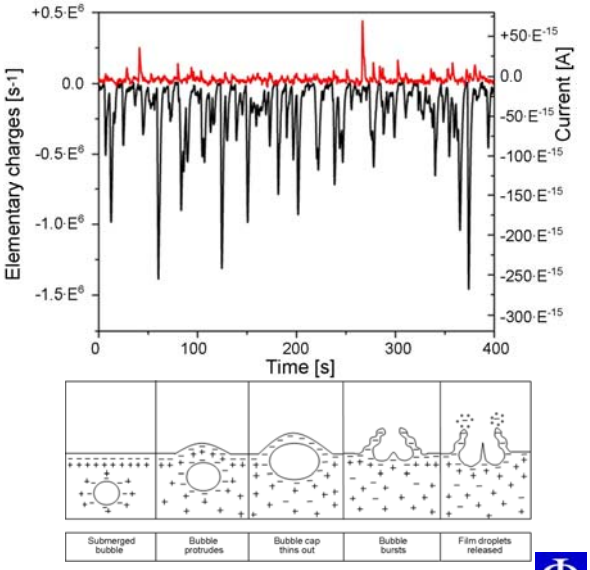
Compare: Pierce E.T. & Whitson A.L.: *Atmospheric Electricity and the Waterfalls of Yosemite Valley*. J. Atmos. Sci., **22**, 314–319 (1965)

Interpretation of the Results

Interpretation of the Results (1/6)

Charge distribution in Bubble Bursting

Currents @ a bubbling rate of 1 bubble/sec :
i) positive (red)
i) negative (black)



Jarrold , 2010

Charge Separation in Bubble Bursting: Disruption of water surface by splashing, bubbling, spraying, boiling etc. create charge separation and produce electrically charged water droplets …. Although research in this field dates back to 18th century with the observation of negative mist at the base of waterfall by Lenard, the complicated structure of water surface was an impediment to understand the charge separation phenomenon completely.

Bubbles of 2.4mm diameter are produced by controlling nitrogen flow though a capillary. The charge on the ions is then detected by a commercial air-ion counter.

The charge separation is chaotic as seen in the figure. There are not as many peaks as the number of bubble burst which shows that the number of film droplets formed may vary widely. The negative current trace has numerous large and sharp peaks whereas the positive current trace has a lot less number of peaks. The total charge on the positive side is usually <15% of the total negative charge.

Source: Bhattacharyya I, Maze JT, Ewing GE, Jarrold MF (2010) Charge Separation from the Bursting of Bubbles on Water. J. Phys. Chem. A.Vol.115: 5723-5728. www.indiana.edu/~nano/research/water.html

Interpretation of the Results (2/6)

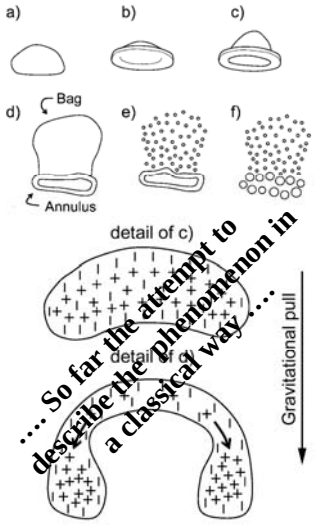
Charge distribution in Bubble Bursting
Why do water droplets possess a negative charge?

i) electrical double layer at the surface.
i) charge separation during aerodynamic breakup
- positive charge carried by large fragments &
- negative charge carried by smaller fragments

(OH^- ions attracted to the positive end of the surface dipoles, the H_3O^+ ions swept into annulus. Upon breakage it generates a large number of small negatively charged fragments, and a small number of large positively charged fragments).

i) net charge of aerosol: **approx. -100mV!**

Zilch et al., 2008



The charge separation associated with splashing and bubbling of water has .... been attributed to the presence of an electrical double layer at the surface of water, where the outermost layers acquire an excess negative charge. There is strong and compelling support for this view from electro-phoretic mobility measurements for air bubbles in water, which show that they move as if they have an **excess negative charge** .... **which is not yet fully resolved**. It probably follows from oriented dipoles at the water-vapor interface (... laid out already 80 years ago). Spectroscopic measurements at the interfacial region of water have shown that 20-30% of molecules exhibit dangling hydrogens. This leaves 70-80% of interfacial water dipoles with their positive end directed toward the water interior …. This picture is also confirmed by surface potential measurements. The accepted value for the **surface potential of water is +0.10 V** …. Furthermore, studies of the charge separation in the aerodynamic breakup of water droplets have shown that the positive charge is carried by large fragments (e.g. H_3O^+) and the negative charge is carried by much smaller fragments (e.g. OH^-).

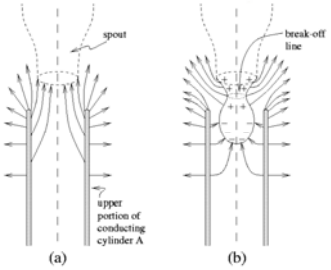
The figure illustrates how such charge separation could occur. Excess OH^- ions are attracted to the interfacial region by the positive end of the surface dipoles. As the bag forms and thins, the H_3O^+ counter-ions are swept into the annulus. When the bag breaks it generates a large number of small negatively charged fragments, and when the annulus breaks it produces a small number of large positively charged fragments ….

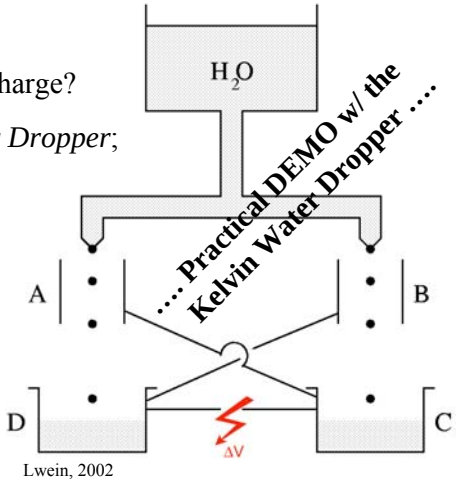
Source: Zilch L.W., Maze J.T., Smith J.W., Ewing G.E., Jarrold M.F. (2008) Charge Separation in the Aerodynamic Breakup of Micrometer-Sized Water Droplets.*J. Phys. Chem. A* 2008, *112,* 13352–13363

Interpretation of the Results (3/6)

Charge distribution in Bubble Bursting
Why do water droplets possess a negative charge?

i) **charge separation** with the *Kelvin Water Dropper*;
i) a battery powered by gravity;
i) can reach up to **several kV!**





Lwein, 2002

Kelvin Water Dropper - a mind-boggling battery: It is a battery that produces a potential difference up to 10-20 kV. There is bucket of water on the top …. water can run out both on the right and on the left via two nozzles, dripping through two conducting sleeves (A & B) into to metal cans (D & C). Sleeve A is electrically connected with can C and sleeve B, with can D. If one lets the water run for a while, there will be a spark jumping b/w the terminals - which are some 5 mm apart. …. A potential difference of something like 10-15kV is required to generate that spark.

Working principle: The water falling into the left cup must carry a tiny net electric charge of *opposite* sign relative to that falling into the right cup. If e.g. the falling drop on the left is, negatively charged and the falling drop on the right is positively charged, one can immediately see the buildup of negative charge of the conducting system (B-D) and positive charge of the conducting system (A-C). The more drops fall, the faster the voltage difference grows until to a critical field value of ~$3 \cdot E^6$ V/m, where the sparking threshold of air is reached. Hence, a minute perturbation grows larger and larger until a "disaster" strikes (here, the ionization of air). The "Kelvin Water Dropper" **converts gravitational potential energy into an electrical charge**.

HOW does water get charged and **WHY** is there a tendency for water to acquire a negative charge on one side of the apparatus and a positive charging-up on the other? A hypothetical event could look like this:

By some tiny *accidental* perturbation, cylinder A acquires a minute, lets say, positive charge. If there were no water near the spout, the electric field lines at the upper rim would look something like the lines shown in the left sketch (a). Notice that water has a pH of 7, that is 10 in $1 \cdot E^6$ water-molecules dissociates into OH^- and H^+). As a result of the external field (a), the H^+ will be somewhat pushed up and the OH^- pulled down. Thus, there is an induced charge separation (b) when a conducting droplet is "exposed" to this external field.

From sketch (b) it becomes clear that, when the thread of water fragments into droplets along the dotted field-lines, some of the upper (positive) polarization charge will be left behind in the water spout. Thus the separated water drop becomes *negatively charged* upon fragmentation. Due to the wiring, a forced charge separation is induced on cylinder B (equi-potential surface charge B-D). The perturbating field on site B has line patterns like those shown in sketch (a), except the directions of lines are *reversed.* Thus, the breaking water drop entering into cylinder B will carry a *positive* charge. The charge left behind in the right-hand side spout is negative, whereas that in the left-hand side is positive.

What about the fate of the charges left behind in the two spouts of the glass tubing? Notice that they are of opposite sign; thus **the water in the tubing and the tank *does not* charge up**. There is, however, an electric current in the water contained in the tubing. If both the tubing and the liquid were good insulators the machine would not work. The remaining charge at the spouts could not be removed (no current could flow through the liquid or tubing from one spout to the other), and the charge separation process in the liquid would quickly come to a halt. It is therefore essential that either the tubing or the liquid has modest conducting qualities

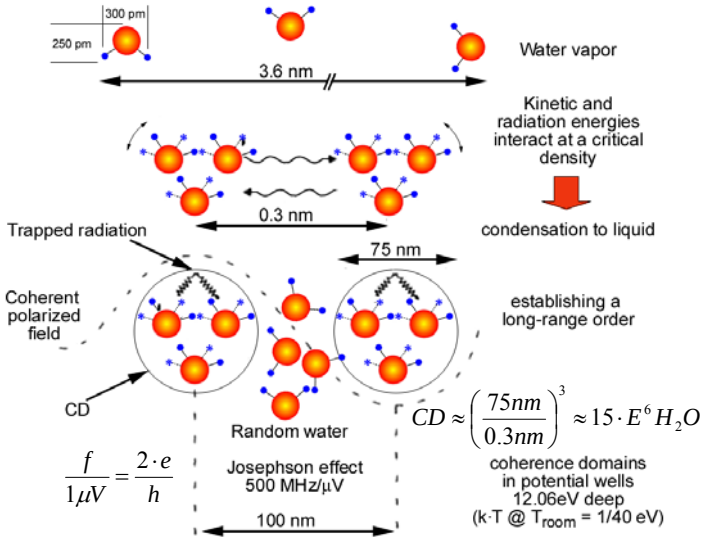
Source: Prof. Lewin @ MIT Physics class – series II (Spring term 2002).
http://ocw.mit.edu/courses/physics/8-02-electricity-and-magnetism-spring-2002/assignments/

Interpretation of the Results (4/6)

QFT of super-radiance applied to water

i) Network of flickering H-bonds (Pauling)
i) CDs form when **vapor condenses** onto liquid phase (droplet).
i) Formation of a CD (**coherence domain**) is a fundamental property of H_2O.

Arani et al., 1995



Gases are fully **non coherent** systems. **Liquids** are systems where **electron clouds** are **coherent**. **Solids** are systems where **nuclei too** are **coherent**. Liquid water is peculiar, since the coherent oscillation connects two electronic configurations that have extreme features:[3]

1) the ground configuration where all electrons are tightly bound (the ionization potential is 12.60eV, corresponding to soft X-rays / far UV-range and to an excitation temperature of $140 \cdot E^3$ [K] …. $E = k \cdot T$ …. $k = 86.174 \cdot E^{-6}$[eV/K];
2) the **excited configuration** has an energy **E=12.06eV**, only **0.54eV below the ionization** threshold. So **for each molecule there is almost one free electron** ($e_{charge} = -1.6022 \cdot E^{-19}$ [A·s] = 1eV)!

Vapor is a superposition of 0.87 F_{nC} and 0.13 F_C; i.e. in a **coherence domain** (CD with a size of 0.1μm) there are **13% almost free electrons per molecule**. The coherent fraction (F_C) is *about* ½ at room temperature.[3] The EMF is trapped within the CD and falls off exponentially out of it (see next slide).

Electrons (much lighter than nuclei) **are repelled outwards** so that **molecules get stretched acquiring electric dipoles** oriented outwards. **The almost free electrons then are further pushed away** from the molecular electron core, so that their distance (d) could reach up to 0.70 Å = 70pm. [3] …. **similar to the SKIN effect** in HF-conductors (see next slide).

A polarized region arises on the boundary of the CD, that gives rise to a charged double layer thick 2δ, where the distance between two neighboring charged layers is 0.35 Å<d<0.70 Å. We get a capacity per unit surface (20μF/cm²) and a charge per unit surface (2.2μC/cm²) . The electric potential difference ΔV of the layer in thus 55mV< ΔV< 110 mV.[3]

DelGiudice et al remarked that "…. *Fröhlich*'s proposal states that density of electric polarization was the "ordering parameter" relevant in biological systems and leads to a scheme for living systems with a finite size related to a non-vanishing temperature, the confinement of the internal EM field into filaments, low intensity coherent electromagnetic emission from living matter, magnetic flux quantization and Josephson-like effects, solitons on molecular chains and water electrets". [1] The Josephson effect is a flow of current across two weakly coupled superconductors, separated by a very thin insulating barrier. The Josephson junction — two superconductors linked by a non-conducting barrier — allows that flow thereby crossing the barrier (Josephson current).[2] The e-accumulation w/n the CDs enable e-tunnelling through the e-deprived non-coeherent insulator.

$f = 2 \cdot e \cdot V/h$ …. $= 483 \cdot E^6$ [Hz/μV] … $e = 1.602 \cdot E^{-19}$[C] = 1[A·s/V] & $h = 6.626 \cdot E^{-34}$[J·s]

Image: Using QED they it is possible to show that water at 300K is a mixture comprising 28% coherent water in 75nm domains interspersed with the remaining 72% as incoherent or vapour-like water. It is the coherent water that reveals "memory" properties. The incoherent water is responsible for its normal thermodynamic properties. This theory is the first to give the experimentally determined values for many of the physical properties of water including: critical volume; boiling temperature; latent heat of vaporisation; specific heat; the specific heat and compressibility anomaly at 230K; the density anomaly at freezing point and the low frequency dielectric constant for water.[1]

Source: [2] http://en.wikipedia.org/wiki/Josephson_effect
[1] Arani,R. Bono, I. Del Giudice, E. Preparata, G. (1995) *QED Coherence and the Thermodynamics of Water*. Intl. J. of Mod. Phys.B, 9: 1813-1841
[3] DelGiudice, E. (2008). Quantum Electrodynamical (Qed) Coherence and Interfacial Water. 3rd Annual Conference on the Physics, Chemistry and Biology of Water, Mt. Snow, Vt. USA 16-19 October.

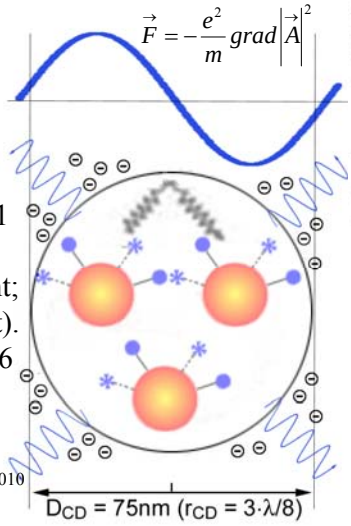
Interpretation of the Results (5/6)

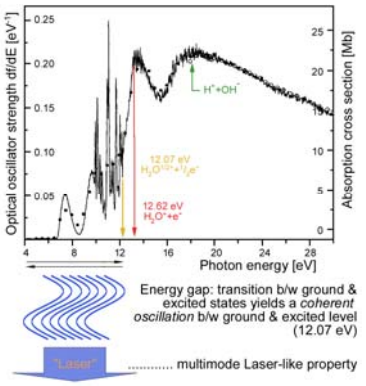
QFT of super-radiance applied to water

i) Two-phase system:
FCD(T) + FnCD(T) = 1
i) CDs are reservoirs of free e- (= reducing agent; bulk water is an oxidant).
i) NCD : NnCD = 0.4 : 0.6 @ T_{Room} !
i) Multi-mode Laser.

DelGiudice & Tedeschi., 2010

$$\vec{F} = -\frac{e^2}{m} grad \left|\vec{A}\right|^2$$





Energy gap: transition b/w ground & excited states yields a *coherent oscillation* b/w ground & excited level (12.07 eV)

"Laser" ..... multimode Laser-like property

$$\left|\vec{E}\right| = \left|\frac{\partial \vec{A}}{\partial t}\right| = 84 \cdot E^9 [V/m]$$

Amplitude w/n CD

Same ω & φ

Arani et al. explain coherence as follows: It arises from the exchange of radiation at the **natural photo-absorption resonances of the water molecule**. This coherence is confined to domains of size determined by the coherence length which is twice the wavelength of the spectral line involved. The **12.06 eV spectral line in the far-UV** and close to the ionisation potential of water is used for the calculations. It yields a **coherence domain once water vapour condenses to the liquid phase**. The authors show that a permanent coherence becomes established in water and give rise to a long-range-order within domains 75nm in size .... in the unexcited or ground energy state of water. It is a fundamental property of liquid water and unlike the laser, no energy pumping is required to establish coherence. [3]

K.Hepp and *E.Lieb* discovered that the archetypical physical model of the laser, the *Dicke Hamiltonian* (p.106) …. is a new peculiar state where a large, classical electromagnetic field gets trapped inside the atomic ensemble oscillating in phase with the atomic transitions between the ground state and the particular excited state that gets singled out in *Dicke*'s model. [1]

Inside a CD …. the coherent electromagnetic field is kept trapped (r_{CD} = λ·3/8) by a mechanism analogous to the well known total reflection that is experienced by light at the interface between two media of different refraction indices.[1]
The evanescent waves of CDs penetrate into each other and produce a net attraction that leads to the condensation of the homogeneous phase.[1]
The influence of the coherent field *A* (EM-vector potential p.110) results in a net attraction, a sort of van der Waals interaction, with the crucial (and appalling) difference that the range now is of the order of 1000 *A* (100nm – see previous slide).[1]

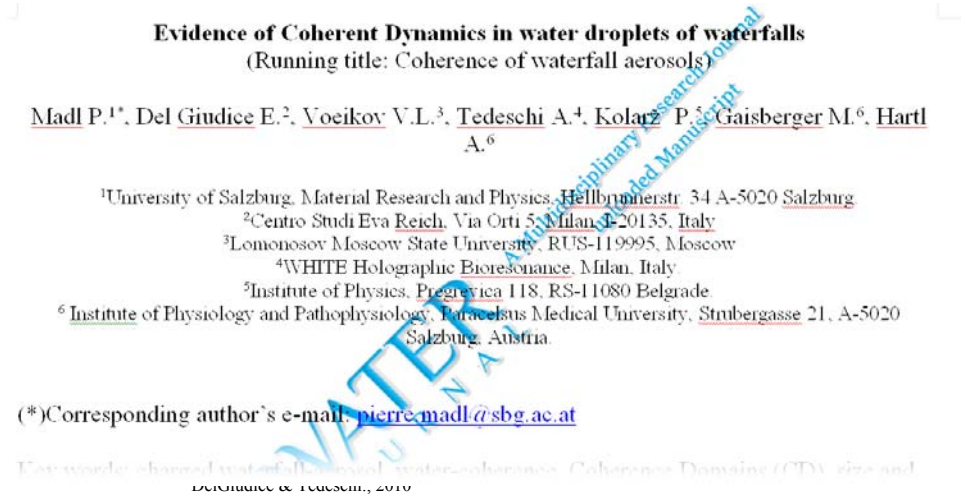
At the boundaries of CD's in the region where the coherent EMF becomes "**evanescent**", a static ponderomotive force* appears whose dependence on the masses of the particles acted upon, implies that only the **electrons are affected, being pushed outward at the CD's boundaries** (similar to the SKIN-effect). In this way the (bio-)molecules at the boundaries of a CD get stretched, acquiring an electric dipole that is directed inward.[1]

It is clear now that as long as the "vapor" density remains below the smallest of the critical densities (0.31g/cm³) that belongs to the level at 12.06 eV, the system of water molecules remains in the pertirbative ground state (PGS = quantum fluctuations away from the coherent ground state), whence it "runs away" as soon as such critical density is reached. When this happens the e.m. "zero-point" **fluctuations** with frequency ω = 12.06 eV **start to build up and the water molecules will begin to oscillate between the ground state and the excited level** at 12.06 eV: all the other levels will be from now on totally ignored by the dynamical evolution of the physical system: water molecules plus EMF.[2]

(*) ponderomotive force: is a non-linear force that a charged particle experiences in an inhomogeneous oscillating electromagnetic field. The F-equation means that a charged particle in such an field not olny oscillates with ω,but also drifts towards the weak field area (movement is independent of the particle charge) …. http://en.wikipedia.org/wiki/ponderromotive_force

Source: [2] Preparata, G. (1995) *QED Coherence in Matter*. World Scientific, Singapore; p.195-217
[1] Del Giudice, E. Preparata, G. (1994) Coherent Dynamics in Water as a Possible Explanation of Biological Membranes Formation. *Journal of Biological Physics* 20: 105-116
[3] Arani,R. Bono, I. Del Giudice, E. Preparata, G. (1995) *QED Coherence and the Thermodynamics of Water*. Intl. J. of Mod. Phys.B, 9: 1813-1841

Interpretation of the Results (6/6)



Evidence of Coherent Dynamics in water droplets of waterfalls
(Running title: Coherence of waterfall aerosols)

Madl P.[1*], Del Giudice E.[2], Voeikov V.L.[3], Tedeschi A.[4], Kolarž P.[5], Gaisberger M.[6], Hartl A.[6]

[1]University of Salzburg, Material Research and Physics, Hellbrunnerstr. 34 A-5020 Salzburg
[2]Centro Studi Eva Reich, Via Orti 5, Milan, I-20135, Italy
[3]Lomonosov Moscow State University, RUS-119995, Moscow
[4]WHITE Holographic Bioresonance, Milan, Italy
[5]Institute of Physics, Pregrevica 118, RS-11080 Belgrade
[6] Institute of Physiology and Pathophysiology, Paracelsus Medical University, Strubergasse 21, A-5020 Salzburg, Austria

(*)Corresponding author's e-mail: pierre.madl@sbg.ac.at

It is the scope of this paper to propose an additional charging mechanism of waterfall generated aerosols. The observations leading to this approach arose from a field study at five waterfalls in the Austrian Alps. Thereby, size distributions of ion clusters, their mobility and their intermediate progenies near waterfalls have been measured with a tandem ion spectrometer consisting of three aspirated Gerdien Cylindrical Ion Detectors (CDI) in combination with a Scanning Mobility Particle Sizer (SMPS). It was observed that the concentration of negative 0.9-10 nm ions was 2-3 orders of magnitude higher than at the reference points up to several 100s of meters away from the waterfalls. Here we discuss the observed features in a quantum electro-dynamic scheme. We find good agreement between theory and observations obtained in the field, which demonstrates that water in this size range is highly structured and coherent.

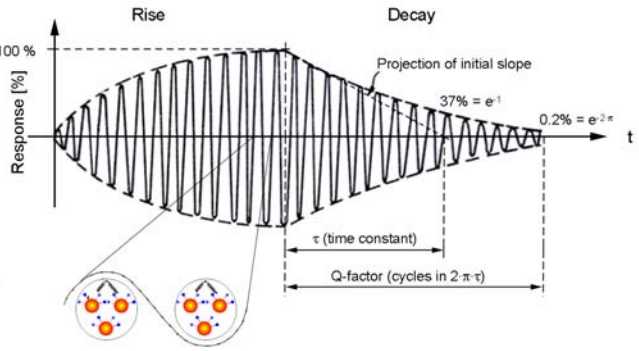
Source: Madl P., Del Giudice E., Voeikov V.L., Tedeschi A., Kolarž P., Gaisberger M., Hartl A. (2013) Evidence of Coherent Dynamics in water droplets of waterfalls. Submitted to Water Journal.

Interpretation of the Results (6/6)

QFT of super-radiance applied to water

i) Size of CD ~100nm (@ STP). $\lambda = h \cdot c/E$, trapping EMF.
i) Peculiar properties of CD_{H2O} (density anomaly, viscosity, spec. heat capac.).
i) when in **contact with membranes, such water becomes extremely ordered**.

DelGiudice & Tedeschi., 2010



Effect on surfactant: 200 µm thick layer ≈800·E³ H_2O molecules!

$$\frac{l_{EZ}}{d_{H2O}} \approx \frac{200\,\mu m}{250\,pm} \approx 0.8 \cdot E^6!$$

The "Classical Electromagnetic Field" describes physical states for which the phase is well defined but the number of particles (quanta) is undefined. For a "Quantum Field" the uncertainty of the phase (Δφ) and the number of particles (ΔN) is determined by the Heisenberg Uncertainty Relation ($\hbar = h/2\cdot\pi$): $\Delta\varphi\cdot\Delta N \geq \hbar/2$ [2]

Within a coherence domain (CD) the phase coherence increases as the number of particles in the domain is allowed to fluctuate. The more the uncertainty is taken up by fluctuation of the number of particles comprising a domain the more perfect is the coherence. In the above figure, the phase coherence would be "Classical" if a very large number of clocks were involved (the actual number not being specified). It would be "Quantum" if the uncertainty in the phase (all pendula swinging in unisono) and the number of clocks involved is determined by the Heisenberg Uncertainty Relation.

Within a coherent system, the range of the coherence (*coherence length*) becomes the constant quantity instead of the propagating wave velocity. This makes frequency proportional to velocity apparently without restriction, so long as one remains within the coherence length. There can be many velocities each with a proportionate frequency; there can be as many frequencies as there are possible velocities. Frequency no longer has an absolute value, the system has become *fractal in frequency*.

If the oscillation is moving through space, the distance travelled per cycle is the wavelength. For such a wave, the frequency multiplied by the wavelength gives its velocity of propagation ($v_{wave} = \nu\cdot\lambda$ [m/s]).[1]

The more precise the frequency, the narrower is the band-width (measured between the half-power points) **and the longer the resonance takes to build-up and to decay** (its echo). This is also measured by the parameter '**Q**' (frequency/bandwidth). The quality (Q) of a resonance expressed within a CD is the sharpness of a resonance and the response rate: $Q \sim f_r/\Delta f$ (…. inversely proportional to the fractional energy loss per cycle).

Two waves can have the same frequency and wavelength, but it may not be possible to superimpose them, because of a difference in phase. If the phases of two waves of the same frequency differ by half a cycle, they would be mirror images and if combined they would cancel each other - this is called destructive interference. **Coherence is then a measure of the capacity of two waves to interfere** (constructive interference).

Dielectric measurements suggest that molecules might cooperate in a fluid over a distance such that the relaxation time is about three orders of magnitude the single molecule rotation time. This argument suggest a size of the CD of about 1000 Á (**100nm**), which corresponds to the wavelength of light emitted in an electron transition.

Source:
[1] DelGiudice E., Tedeschi A. (2009) Water and the Autocatalysis in Living Matter. Electromagnetic Biology and Medicine, 28: 46-54.
[2] DelGIudice E., Spinetti P.R., Tedeschi A. (2010) Water Dynamics at the Roots of the Metamorphosis in Living Organisms. Water (in press).

Exclusion Zone (1/2)

Why do CDs matter:

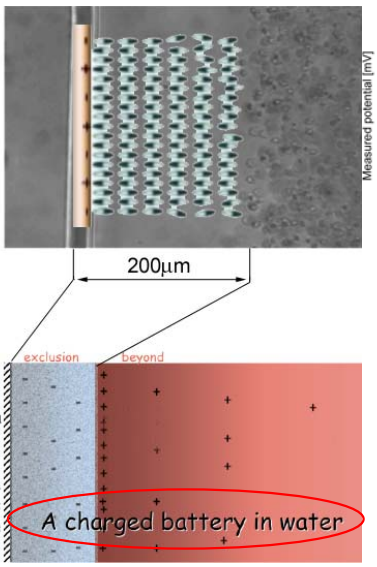
i) buildup of Exclusion Zones (EZ) on membranes.

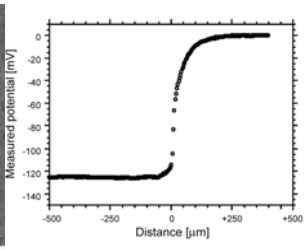
$$\frac{l_{EZ}}{d_{H2O}} \approx \frac{200\,\mu m}{250\,pm} \approx 0.8 \cdot E^6!$$

i) Creating potential gradient with wider surrounding.

i) Pool of **free electrons** available for facilitating:
- **membrane potential**
- **RedOx-reactions**.

Pollack, 2008 & DelGiudice et al., 201(





Video: EZ & "4th state of water" (08:15-11:13)

In bulk water the combination of EMF and thermal fluctuations (k·T) produces a flickering situation, where CDs are prevented to exhibit their peculiar features for a time long enough to allow detection. However, near a hydrophilic surface, provided that the attraction energy per molecule is of the order of k·T, the effect of thermal assaults is screened and water is almost entirely coherent on a range increasing with the electric polarisation of the surface. Since this interfacial water is almost fully coherent in a permanent way its "effective temperature" should be lower than the temperature of bulk water. Moreover, since solutes can be dissolved in the non-coherent fraction only, they cannot be present in the interfacial water (exclusion zone water = EZ water).

On the boundary of this thick layer, there is a potential difference expressed as 20µF/cm² or a charge of 2.2µC/cm² per unit surface area equivalent to 55mV< ΔV< 110 mV. This is in surprising agreement with the membrane potentials. Is it conceivable that is not the lipidic (hydrophobic) membrane to produce the potential, but, vice versa, the potential generated by EZ water to generate the variations in the solute molecule concentrations that appear as membranes?[1]

The EZ is so-called because it excludes solutes, i.e., substances dissolved in the water. By putting into the water solutes large enough to be seen under the microscope, or even with the naked eye, the EZ shows up as a region completely clear of the solute. Thus, when a suspension of microspheres 0.5 to 2 mm in diameter is put into a chamber with the gel, a clear zone, free of microspheres soon develops next to the gel and typically ends up hundreds of microns thick. This EZ is stable if undisturbed, for days and weeks once it is formed .... And is so enormous that at least hundreds of thousands of layers are involved.[4]

In standard QED, it is possible to show that a molecule able to oscillate on a frequency ν is strongly attracted in a region where there is an extended EMF resonating on the same frequency (laser cooling). The oscillation frequency of water CDs is 0.26eV at T=0°C and about 0.2eV at room temperature. Thus a non aqueous molecule is attracted in the CD if a frequency ν is present in its spectrum such that | ν -0.2eV| ≤ k·T.

For a given temperature this Equation tells us which molecules are candidates to be co-resonant partners of water (i.e. bio-molecules) or, alternatively, for a given set of molecules what is the interval of temperature where they can resonate.

Coresonating molecules can join the water-CDs and participate in the coherent dynamics. In water-CDs there is a reservoir of almost free electrons, whose (1) energy is –0.54eV+X (X is 55mV<ΔV<110mV) may tunnel out from CDs according to quantum tunnel effect, provided that they find out of the CD a site having the same energy. By assuming X ≈ 0.1eV Eel ≈-0.44 eV that coincides with the electronegativity of O_2!

Thus $(H_2O)COH + O_2 \rightarrow H_2O^+ + O_2^-$ is the starting point of a chain of events that ends with the splitting of the water molecule. The almost free electrons are able to receive energy from outside producing coherent cold vortices where electrons move without colliding. Then their lifetime could be quite long! It is possible to induce more and more vortices that sum up storing large amounts of energy.

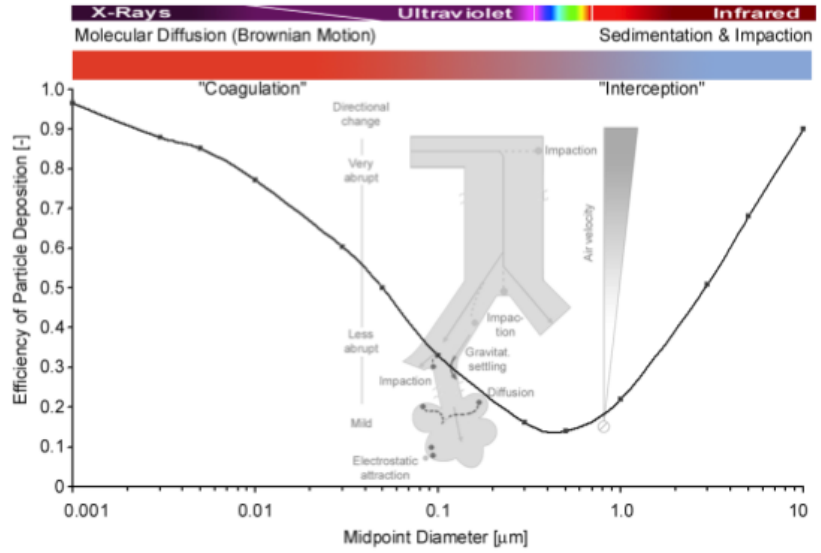
Water CDs thus became devices able to transform low-grade (high entropy) energy collected in the environment into high grade (low entropy) energy able to induce into the "guest molecules" that have joined the CDs electronic excitations. Since these "guest molecules" are coherent, they are no longer independent and can receive energy only in a collective way in one stroke as in multimode lasers! This produces biochemical codes !

Water CDs can thus get excited by collecting ambient energy and get de-excited by activating "guest molecules" producing so a CD-oscillation. This oscillatory regime allows the onset of a coherence among coherence domains that tune together the oscillations of single CDs. In this way coherence extends on regions, whose size depends on the frequencies of CDs that depend in turn on the rates of chemical reactions. The output energy of chemical reactions load again the CDs, changing their oscillation frequency.

Potential profile as a function of distance from the polyacrylic-acid-gel surface. Surface located at "0" on the abscissa. Inside of gel is to the left of "0"; outside of gel is to the right. Reference electrode is positioned well to the right.[3]

Source: [1] DelGiudice, E. (2008). Quantum Electrodynamical (QED) Coherence And Interfacial Water. 3rd Annual Conference on the Physics, Chemistry and Biology of Water, Mt. Snow, Vt. USA 16-19 October.
[2] Pollack G.H. (2010). Water, energy and life: Fresh views from the water's edge. Int. J. Of Design & Ecodynamics. Vol 5. No.1: 27-29.
[3] Zheng J-m, Chin W-C, Khijniak E, Khijniak E Jr and Pollack GH. Surfaces and interfacial water: evidence that hydrophilic surfaces have long-range impact. *Advances in Colloid and Interface Science* 2006, 127, 19-27.
[4] Ho M.W. (2008). Liquid Crystalline Water at the Interface. ISIS. http://www.i-sis.org.uk/liquidCrystallineWater.php

Exclusion Zone (2/3)



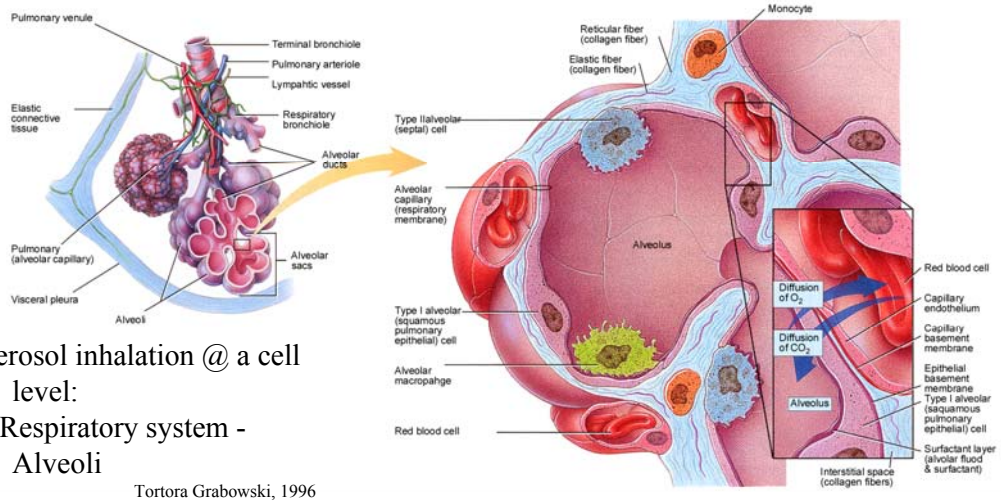
Inhalation of Aerosols: The average human lung with a tidal volume of 500 mL (at rest) and a ventilation rate of 15 breaths per minute (21.6·E³ breaths per day) exchanges 7.5 L per minute (10.8·E³ L/day), enables a large enough fraction of nano-particles to be inhaled and filtered out by the lungs. During human evolution, we always have been exposed to aerosols, and indeed a certain load of aerosols is well tolerated in a healthy individual.

Particle Deposition: Obviously, larger and heavier particles in the size range from 1 to 10 □m are readily deposited by impaction and sedimentation in the upper respiratory tract (Fig. 15). **Impaction** occurs when the particle's momentum in the air stream prevents it from following the bifurcation turns within the respiratory tree. Impaction events take place in the naso-pharyngeal and tracheo-bronchial region. If **sedimentation** predominates than it simply means that gravitational forces acting on the inhaled particles are greater than air resistance and buoyancy, the particle will simply fall out of the air stream.
The elevated relative humidity within the respiratory tract of 99.95 % (supersaturated conditions) makes sure that hydrophilic particles even from the accumulation mode behave like CCNs once inhaled; i.e. they rapidly adsorb water from the humidified air. This effect not only increases the overall density of these particles but also boosts particle growth, which in turn favors deposition by impaction and sedimentation mechanisms presented above thereby facilitating bronchial particle clearance.
Due to the branching nature of the lung, an inhaled air bolus moves slower and slower the deeper it penetrates into the lung. A decreasing air flow rate then allows **diffusion** processes to take over. Inhaled nano-particles behave according to Brownian motion thereby favoring random impacts with the lining of the lung. Diffusion processes occur in the **bronchial** and **pulmonary** compartments of the lung and to significant part in the nasal cavity, i.e. olfactoric region

The graph is a superposition of diffusion (ascending right half of the curve) and impaction & sedimentation (descending left half of the curve) processes. Subimposed is a schematic view of the pulmonary domains, with the naso-pharyngeal and tracheo-bronchial pathway at the top and the bronchiole and alveolar regime at the bottom, alongside the flow velocities of the in- /exhaled air.

Source: Madl P. (2009) Anthropogenic Environmental Aerosols. http://biophysics/exotica/thesis-piero2.pdf

Exclusion Zone (3a/3)



Aerosol inhalation @ a cell level:

i) Respiratory system - Alveoli

Tortora Grabowski, 1996

Portion of a lobule of the lung: Each broncho-pulmonary segment of the lungs has many small compartments called lobuels. Each lobule is wrapped in elastic connective tissue and contains a lymphatic vessel, an arteriole, a venule and a branch from a terminal bronchiole. Terminal bronchioles subdivide into microscopic branches called respiratory bronchioles. As the respiratory bronchioles penetrate more deeply into the lungs, the epithelial lining changes from simple cuboidal to simple squamous. Respiratory bronchioles in turn, subdivide into several alveolar ducts. From the trachea to the alveolar ducts, there are about 25 orders of branching of the respiratory passageways. That is, the trachea divides into primary bronchi (1st order), the primary bronchi divide into secondary bronchi (2nd order) snf do on.

Around the circumference of the alveolar ducts are numerous alveoli and alveolar sacs. An alveolus is a cup-shaped outpouching lined by simple squamous epithelium and supported by a thin elastic membrane. Alveolar sacs are two or more alveoli that share a common opening. The alveolar walls consist of two types of alveolar epitheli cellsor pneumocytes. Type I alveolar (squamous pulmonary epithelial) cells are simple squamous epithelial cells that form a continuous lining of the alveolar wall, interrupted by occasional type II alveolar (septal) cells. The thin type I alveolar cells are the main site where gas exchange takes place. Type II alveolar cells are rounded or cuboidal epithelial cells whose free surfaces contain microvilli. They secrete alveloar fluid, which keeps the alveolar cells moist. Associated with the alveolar wall are alveolar macrophages (dust cells). These wandering phagocytes remove fine dust particles and other debris in the alveolar space. Also present are fibroblasts that produce reticular and elastic fibers. Superficial to the layer of type I alveolar cells is an elastic membrane. Around the alveoli, the lobule's arteriole and venule disperse into a capillary network. The blood capillaries consist of a single layer of endothelial cells and basement membrane.

Source: [1] Tortora G.J., Grabowski S.R. (1996) Principles of Anatomy and Physiology, 8th ed., Addison Wesley Longmann Inc. USA

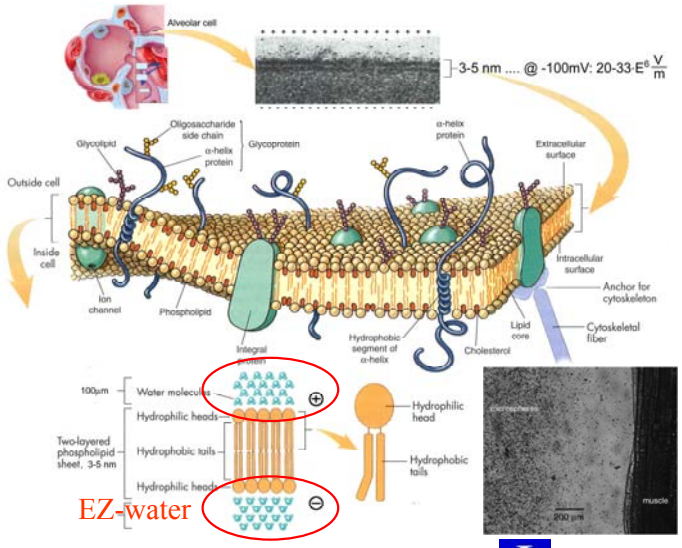
Exclusion Zone (3b/3)

At a molecular level:

i) Plasma membrane (3-5nm thick)
i) interstitial (+), cytosol (-)
i) Formation of EZ-structures on both sides of the cell membrane

EZ: 200µm = thickness of $800 \cdot E^3$ H_2O molecules!

Tortora & Grabowski, 1996, Posthlethwait, 1995, Randall et al., 1997, Zheng et al., 2006



The Plasma Membrane: The plasma membrane is a lipid bilayer, two tiers of phospholipid molecules with hydrophilic heads on the membrane's surface, and hydrophobic tails oriented inward toward the middle of the membrane. The Singer-Nicolson fluid mosaic model of the membrane is widely accepted. The plasma membrane is pictured as a fluid plane with floating "icebergs"-proteins that can extend through the membrane and project from either or both sides. The globular integral proteins embedded in the lipid bilayer provide a mechanism for trans-membrane transport. The inner mitochondrial membrane would have an even higher protein content and thus less lipid bilayer than this figure represents. *Glycoproteins* act as cellular labels and as receptors for incoming chemical signals. Some membrane proteins attach to cytoskeletal fibers.[2] The glycoproteins bear oligosaccharide side chains and are vital for cell recognition and communication. Cholesterol molecules lie close to the heads of the phospholipid molecules, where they reduce membrane flexibility. The inner ends of the phospholipid tails are highly mobile, giving the membrane fluidity.[1]

EZ-layer: Upon insertion of the membrane, the EZ progressively translate away from the gel surface, creating a particle-free zone that continue to expand at~ 1µm/s, leaving a stable ~ 250 µm-wide particle-free zone …. EZs can also be seen adjacent to collagen gels and vascular endothelium, using both microspheres and erythrocytes …. Exclusion process does not require a gel; only a surface with hydrophilic moieties is necessary …. In the case of the polyacrylic acid gel, the magnitude just outside the gel was ~-120 mV, and remained steady at that value as the probe advanced inside the gel …. Indeed, the possibility of water impacted by surfaces raises the question of long-range recognition of complementary entities such as enzymes–substrates, antigens–antibodies, etc. …. Water organization around charged surfaces seems to be a key attribute underlying biological and bio-inspired self-organization …. Solutes in aqueous suspension are extensively excluded from the vicinity of many interfaces, and the evidence presented here supports the view that such exclusion arises from long-range restriction of water molecules, nucleating at the interface and projecting well into the aqueous phase, similar to what occurs in liquid crystals.[3]

Source: [1] Randall D.J., Burggren W., French K. (1997) Eckert Animal Physiology, 4th ed. Freemann & Co. USA.

[3] Zheng J.M., Chin W.C., Khijniak E., Pollack G.H. (2006). Surfaces and interfacial water - evidence that hydrophilic surfaces have long-range impact. Advances in Colloid and Interface Science 127: 19–27

Conclusio

Conclusio (1/2)

The essence in a nutshell:

- Electrostatic field gradient due to prevailin negatively charged ionic aerosols.
- Their minute size (<100nm) facilitate formation of Coherence domains (CD) and Exclusion Zones.
- CDs are prevalent domains in biological systems.
- Inhalation of charged aerosols aids immuno-biological metabolism as the net charge (-100mV) corresponds to the **membrane potential of cells**!

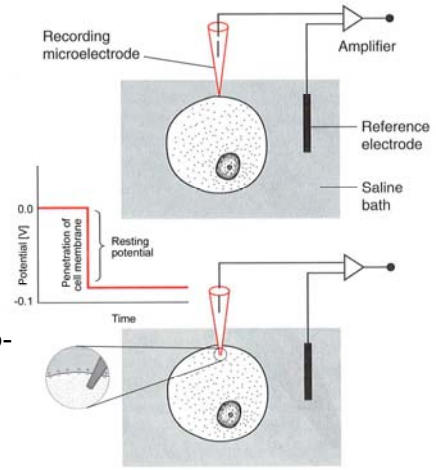


Image: When a microelectrode penetrates a neuron's cell membrane, there is a shift in the recorded potential difference.
Upper image: No potential difference is recorded between the reference electrode and the recording microelectrode when both are in the saline bathing the neuron.
Lower imgage: As soon as the microelectrode tip penetrates the neuron's membrane, the electrode records an abrupt shift in the negative direction, which is shown as a downward deflection on the oscilloscope screen or the computer monitor. This deflection corresponds to the resting potential across the membrane.

Source: Randall D., Burggren W., French K. (1997). Eckert's Animal Physiology, 4th ed. W.H. Freeman & Co. New York, USA.

Conclusio (2/2)

Outlook – some examples:

- Systematic scanning of WF-emitted HF-spectrum (CDs).
- Determination of coherence in aqueous aerosols when mixed with combustion aerosols (coagulation & polarization).
- Coherence-measurements during induced stress-stimulation (diesel-, ETS-aerosols, EMF) and their effects on EZ in cell-cultures.
- Measurements of super-coherence of cell-cultures all the way up to holobionts (lichens, lab-mice, humans).
  i) skin-, mucosa-, eye-measurements (before and after exposure to WF);
  i) fibroblast exposure to WF-related aerosols;
- Effects of coherence and epigenetics – if any.

Thank You for your attention

Further reading:

Madl P. (2012) Exposure to Nano-Sized Particles and the Emergence of Contemporary Diseases with a Focus on Epigenetics. Intech Publ. Available online

http://www.intechopen.com/books/air-pollution-monitoring-modelling-and-health/airborne-particles-and-the-emergence-of-contemporary-diseases