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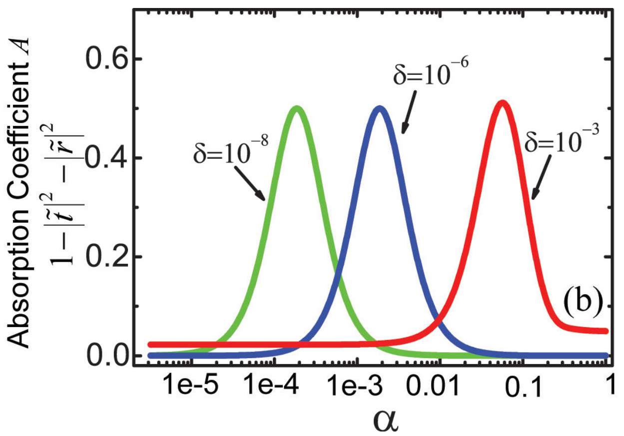
Highlights from the previous volumes

On the transition between complementary medium and zero-refractive-index medium

"Complementary media" in electromagnetics is a concept inspired by the advent of negative-refractive-index media, and can be used to explain how a perfect lens works. Simple examples of complementary media are two homogeneous slabs, one with permittivity and permeability (ε, μ), and the other with opposite signs $(-\varepsilon, -\mu)$. The positive- and negative-index slabs cancel each other such that waves will pass through the system with unity transmittance as well as zero phase change. A zero-refractive-index medium is another class of material that possesses the zero phase change characteristic and unusual optical properties. Zero-refractive media have $\varepsilon\mu \rightarrow 0$.

It can be argued that zero-refractive-index media are a subset of complementary media, however zero-index and complementary media have distinct scattering properties. We showed that by considering the dissipation properly, a metamaterial can change from complementary-like to zero-refractive–like, when the imaginary part of the constitutive parameters is of the order of the square of the real part. In the intermediate region, the metamaterial can absorb up to half of the incident electromagnetic energy in the limit of vanishing absorption coefficients due to a strong field enhancement. The above conclusion remains valid in inhomogeneous systems.

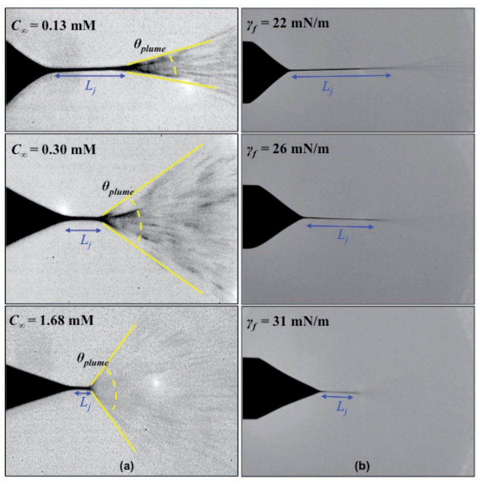


The system consists of two slabs with constitutive parameters $(\varepsilon_1 = \alpha + i\delta,\ \mu_1 = \alpha + i\delta)$ and $(\varepsilon_2 = -\alpha + i\delta,\ \mu_2 = -\alpha + i\delta)$. We plot the absorption coefficient as a function of α. An absorption maximum of 50% can be seen when $\delta \sim \alpha^2$, even though δ is vanishingly small.

Original article by WANG FAN and CHAN C. T.
EPL, **99** (2012) 67002

Electrospray cone-jet breakup and droplet production for electrolyte solutions

Proteomic mass spectrometry and chemical imaging require the generation of nanometer-sized charged water drops that are emitted in a precise direction. This is done with the remarkable ability of an electric field to sharpen a mm-sized spherical drop into a sharp cone with a universal half angle of 49 degrees, to emit a microjet at the cone tip and to break up the charged microjet explosively into a plume of nanodrops, whose plume angle and charge per drop sensitively affect the measurement accuracy of the instrument. This paper captures the underlying nanoscale physics of DC electrospray with a combination of strong electrolyte theory, electrostatics, interfacial phenomena and potential spectral theory for geometric singularities. The electric field of the most singular harmonic near a cone that sharpens the drop is also shown to charge a nanoscale capacitor at the interface of the microjet, with a dimension of the Debye length. The interfacial charging increases downstream of the cone tip until the space charge separation is below the Bjerrum length, when the repulsive Coulombic energy between two charges exceeds the thermal energy. The resulting Coulombic fission accounts for the explosive breakup of the microjet into the nanodrop plume. The microjet length, the charge per nanodrop and the nanodrop plume angle as functions of the ion strength are accurately captured by the theory as functions of the ionic strength and surface tension. Strong ionic strength and low surface tension produce the longest microjet, the smallest plume and the most precisely directed nanodrops.



The microjet length L_j and nanoaerosl plume angle θ_{plume} are observed to be strong functions of the ionic strength C_∞ and interfacial tension γ_f.

Original article by WANG YUNSHAN *et al.*
EPL, **99** (2012) 64003

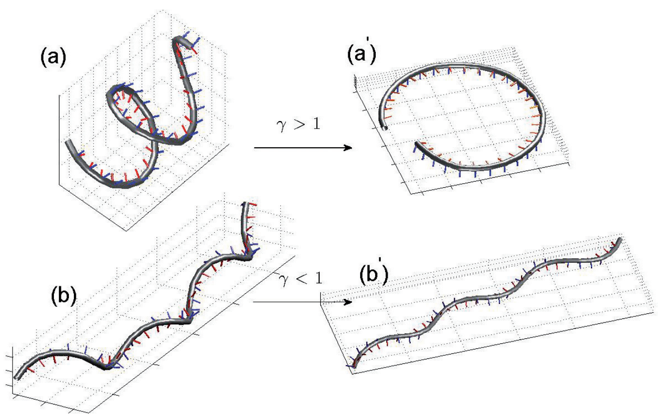
Physics of squeezed helices*

Helically coiled filaments are everywhere in living nature. In experimental situations, filaments are often squeezed flat (or nearly flat) onto two-dimensional surfaces. Under such 2d confinement filament helices form what we call "squeelices" —peculiar squeezed conformations often resembling looped waves, spirals or circles. Many such shapes have been observed and reported for a variety of biological and man-made filaments.

With filament helices being such a ubiquitous structure, we asked the question what happens when filament helices become confined and found that the confinement produces some dramatic changes in filaments shape, giving rise to several notable and surprising effects. In particular "squeelices" can display an enhanced cyclisation probability, unusually strong end-to-end fluctuations and a conformational multistability. The conformational dynamics of confined helices is most naturally described in terms of discrete particle-like entities —which we call the "twist kinks". These "twist kinks" turn out to be analogous and are physically related to crystal dislocations in solids and Sine-Gordon kinks from soliton physics. Twist kinks move thermally along the confined helix and interact much like quasi-particles. Confined helices can further thermally switch between discrete twist-quantized states comprising different numbers of twist kinks.

Doing simple things (confining) to simple objects (helical filaments) can give rise to complex physics.

* This work is part of the PhD of Gi-Moon Nam prepared in co-supervision between UdS and Sejong University. It is supported by the STAR (PHC) exchange program.



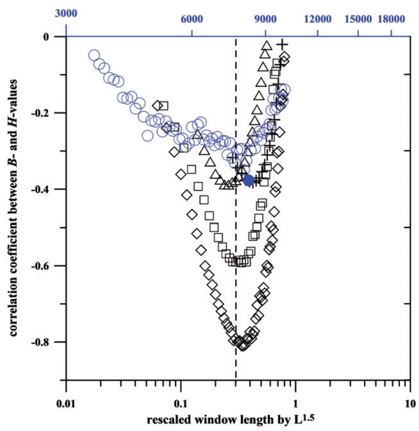
When confined to a surface helical filaments form "squeelices". Two categories of squeelices exist, depending on the sign of the twist kink self-energy (positive and negative for $\gamma > 1$ and $\gamma < 1$, respectively). (a), (b) Typical filament helices in 3D before confinement. (a′), (b′) When confined, (a) transforms into untwisted circularized shapes ($\gamma > 1$) while (b) assumes twisted and wavy shapes ($\gamma < 1$).

Original article by NAM GI-MOON *et al.*
EPL, **100** (2012) 28001

Negative correlation between frequency-magnitude power-law exponent and Hurst coefficient in the Long-Range Connective Sandpile model for earthquakes and for real seismicity

Two parameters of earthquake dynamics are related in this paper: the exponent of the power-law frequency-magnitude and the Hurst coefficient of the magnitude time series. The relationship, analysed for the real Italian seismic catalogue, is explained by using the long-range connective sandpile (LRCS) model. The LRCS model is an $L \times L$ grid derived from the Bak-Tang-Wiesenfeld (BTW) sandpile model, in which the sand grains accumulated on one cell reaching the threshold are not redistributed onto the four adjacent cells (like in the BTW model), but one grain is added on a randomly chosen cell, which may be far from the redistributing cell. The redistribution of sand grains in the LRCS model can be considered, then, as a way of releasing energy with long-range effects like in real earthquake fault systems.

The reliability of the LRCS model was evaluated by means of the frequency size power-law exponent (B) and the Hurst coefficient (H) of the avalanche size time series, whose relationship is mainly negative. For the declustered Italian seismicity, the maximal negative correlation between B and H of the magnitude time series is about -0.38 for a window length of ~ 8200 events. In both model and real seismicity, almost identical rescaled window length was found corresponding to the maximal negative correlation coefficient. As the system accumulates energy, the average avalanche cluster size is increasing as a cell reaches the threshold. The larger the average avalanche cluster size, the larger the chance to induce strong events that have more chance to long-range redistribute their energy and induce more strong events. This implies a lower B; and, due to such long-range triggering, the system becomes more persistent and shows higher H.



Correlation between B and H for different rescaled window length and size L (50 (+), 100 (△), 200 (□), 400 (◇)). Blue circles show the correlation for the Italian seismicity.

Original article by LEE YA-TING *et al.*
EPL, **99** (2012) 29001