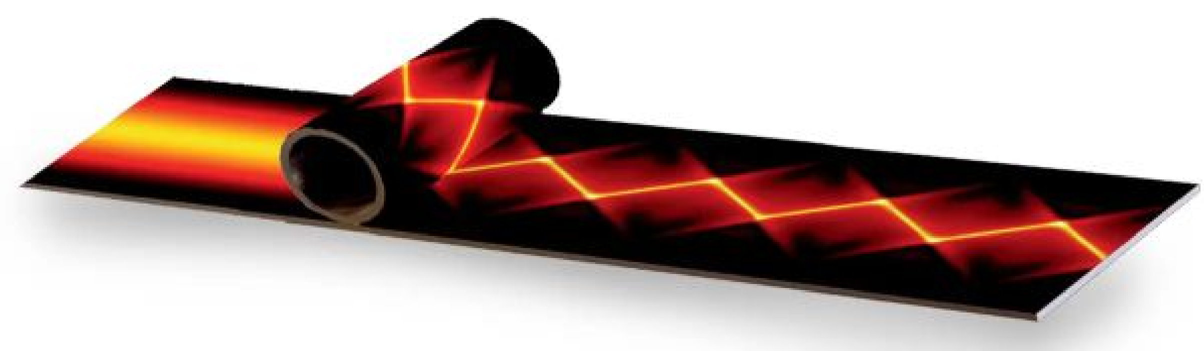

Photonic snakes give rise to a novel type of 2D frequency combs

Researchers provide an innovative framework for the understanding and control of the long known highly destructive snake instabilities. The results have been published in Nature Photonics.

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A team of researchers provides an innovative framework for the understanding and control o the long known highly destructive snake instabilities. These instabilities form stationar nonlinear photonic snakes, which introduce a novel type of nonlinear waves and, mos importantly, provide a generalization of the concept of optical frequency comb

Optical frequency combs are laser-controlled discrete spectra that act as rulers to perfor absolute measurements of the colors of light very quickly and accurately, a resource that i very useful for understanding our modern world. Since optical frequency combs may consis of up to thousands of frequencies carried by ultra-short pulse trains, they are excelle t measuring tools in frequency and time spaces, and hence their applications are manifol , which include ranging, metrology, timekeeping, quantum memories and computatio

, communications, and spectroscopy, among other
. The formation of reliable optical frequency combs at the micron scale became a solid reali
y during the last decade thanks to the use of 1D temporal dissipative solitons. Curre
t applications mostly rely on single or double comb forming devices. However, scientis
s anticipate that with an in-depth understanding of the dissipative soliton physics in high
r dimensions, robust two- and three-dimensional frequency combs could be achieve
, converting frequency combs in a fundamental measuring tool with a much greater potentia
. A cornerstone to succeed along this direction is the control of the ever-increasing number
f the system's instabilities that appear in non-linear optical phenomena when increasing t
e system's dimensions. Such instabilities, when controlled, provide amazing and novel tools f
r observing and understanding new effects and ways to manipulate light-forms. This is t
e case of snake instabilities, discovered almost 50 years ago, which have shown to
e responsible for the reshaping of straight states (of light or else) into zigzag paths (like
a snake), mainly caused by spontaneous and local transverse drift
. The ability to understand this temporary instability in the system and learn how to control
t to form optical frequency combs to harness the process that could lead to the formation
f stationary, permanent, 2D zigzag states, would signify a major change in the field
f non-linear sciences in general and optics in particular. This has recently been accomplis
ed in a study published in **Nature Photonics**. A team of researchers, including ICFO Director Lluis Torner and former ICFO postdoctoral researcher Carles Milian, now a Professor at the Institut Universitari de Matematica Pura i Aplicada, Universitat Politecnica de Valencia, Salim B. Ivars (former Master student at ICFO) and Yaroslav V. Kartashov, have obtained two important theoretical results in the field of nonlinear optics. Firstly, they have discovered how to control the snake instabilities in cylindrical micro-resonators. That is, by using theoretical approaches and numerical simulation tools, they engineered the micro-cavity in which they let the snake instability occur and then by ï¿½freezingï¿½ its effects, they were abl
to achieve a perfectly stationary spatio-temporal zig-zagged optical wave, robust and permanent in time, which they coined ï¿½Photonic Snakeï¿½. Secondly, they theor
tically showed that these photonic snakes correspond to an unprecedented two-dim
nsional arrangement of heterogeneous photonic rulers or 2D frequency combs, which are all inherently synchronized and individually accessible, leading to a novel
nd most sophisticated optica
ruler. These findings represent a novel paradigm for frequency comb formation and pave the way towards a new research approach on frequency combs as well as on the
n-depth understanding and control of dynamical instabilities in dissipative systems. The dis
overies point the way towards a novel class of Broadband and reconfigurable Monolithic Mu
ti-Comb devices, which offer the possibility to deliver different combs on demand and in re
l time, and have the potential to give rise to novel applications as well as broaden the
cope of current existi