R a E ab S G a

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Ab a : We experimentally demonstrate resonant switching and pulse regeneration using a graphene-based excitable fiber ring laser and simulate an analogous integrated device structure. Such devices could find use in pulse regeneration or optical computing.

1. I

Self-switching is one of the simplest nonlinear operations, outputting a signal only if it is above a critical threshold, T. It is the mechanism underlying digital logic buffering, comparators, digital-to-analog converters, and thresholders. We have investigated a novel implementation to self-switching based on the dynamical phenomenon of excitability. A system is said to be excitable if it remains stable in an attracting equilibrium state, can trigger as a result of a small perturbation to produce a large amplitude excursion, and is followed by a refractory period, in which the signal recovers back to the attractor. Its role in lasers has been investigated for some time now [1], but it has garnered renewed interest as a dynamical analogy to spiking neural networks [2, 3]. Excitable systems possess unique pulse generation properties and strong ties to the underlying physics of the devices.

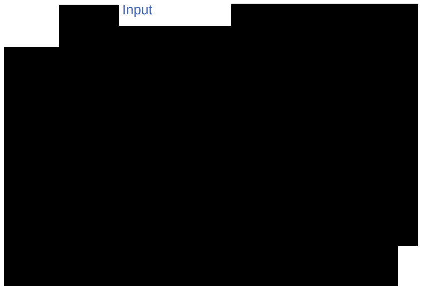
Here, we show resonant excitable self-switching in a graphene-based fiber laser. We demonstrate experimental results and simulate the physical system integrated into a smaller footprint. Unlike other switching approaches, excitability is both cascadable and regenerative, and may offer a unique direction for photonic signal processing.

2. G a F b La

As a prototype, we built a fiber ring laser that exhibits excitability, modified from the original [4]. A schematic is shown in Figure 1(a). It is fundamentally based on the interaction between a gain section, a saturable absorber section—which provides the nonlinearity via Pauli blocking in graphene—and light within the cavity. A $980\ \mathrm{nm}$ pump brings the gain section, an erbium-doped fiber (EDF) above transparency, but saturable cavity losses from graphene prevent lasing. Our input channel is a $1480\ \mathrm{nm}$ signal, which also pumps the EDF. A strong input pulse will bring the gain above the losses, resulting in saturation and the release of an optical pulse. As shown in Figure 1(c), a pulse below the threshold triggers no output, but pulses of different widths—shown in the insets—trigger the same stereotypical output pulse. Our system can be described by a three-dimensional system with nonlinear dynamical variables (power, gain, and saturable absorption) as described in [5]. The absorber was assumed to be instantaneous (since the relaxation time of graphene is much faster than the gain or intensity $\tau_A << \tau_L, \tau_R$). There was a strong agreement between simulation and experiment.

3. I a E ab La S a

The phenomenon shown in our experimental prototype can also be realized in a much smaller, integrated cavity with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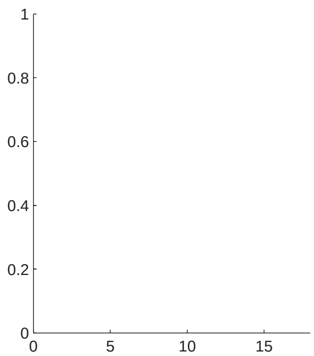
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0.6
0.4
0.2
0
0
5
10
15