would stop. This finding is manifested by the thin sub-wavelength lobes shown in Fig. 1(a), where even the main lobe is about half a wavelength wide. As a consequence, when the beam completes near 90° bending, it breaks up, causing the nonlinear effect to drop quickly, causing most of the beam to decay. For stronger nonlinearities, we expect an even more abrupt decay, causing a larger portion of the power to backscatter. This breaks a fundamental rule of linear optics: linear propagation prohibits the backward radiation to be created from an incident beam in a homogenous medium; the essential reason is simple: forward propagating waves cannot change to become backward propagating waves, so nothing that was launched forward can turn backwards. Indeed, linear wave dynamics do not couple the forward and backward waves. And yet, this rule breaks down in the presence of nonlinear effects, because nonlinearity couples all waves, in particular – in this case it couples the forward and the backward propagating waves. Nonlinear optics allows the nonlinear beam to reflect itself (or part of it) – which is expressed in an effective bend of more than 90°. This beautiful phenomenon is at its best in the nonlinear dynamics of our accelerating beams, since the back-reflection changes from zero - along the propagation, to its maximum - right after the nonlinearity drops. This dynamics suggests the exciting possibility of making a beam that would somehow fully reflect on itself. Such a notion is known in nonlinear optics in the context of phase conjugation; however, here the beams are accelerating (bending), hence the trajectory of such a beam would more resemble a boomerang. Such an envisioned beam will have a 'U' trajectory: it will start propagating along one branch of the 'U' and then bend to propagate back along the other branch of the 'U'. It seems that such a beam is indeed in principle physically possible. However, very high nonlinearities are required to cause enough power to backscatter so that an actual “boomerang soliton” would form. Further study of this phenomenon is left for future research.

Conclusions

We presented shape-preserving nonlinear self-accelerating beams of Maxwell's equations, and analyzed their physical features.

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