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Non-linear media in weakly curved spacetime: optical solitons and probe pulses for gravimetry

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That light propagating in a gravitational field gets frequency-shifted is one of the basic consequences of any metric theory of gravity rooted in the equivalence principle. At the same time, also a time dependent material's refractive index can frequency-shift light propagating in it. The mathematical analogy between the two effects is such that the latter has been used to study the optical analogue of a black-hole spacetime. Here, we combine these two effects by showing that light propagation in non-linear media in the presence of a moving refractive index perturbation can lead to a gravity-dependent blueshift. We find that the predicted blueshift surpasses the gravitational redshift even if the medium is considered to be perfectly stiff. In realistic scenarios, by far the strongest frequency shift arises due to the deformation of the dielectric medium and the corresponding photoelastic change of refractive index. This has the potential to facilitate optical sensing of small gravity gradients.

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