A toy-model for spontaneous Lorentz symmetry breaking in modified BF theories

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In $(1+1)$ dimensions we consider a BF model defined by $\mathbf{B} = \Phi_\mu \, dx^\mu$ and $\mathbf{F} = d \wedge \mathbf{X}$, further extended by a potential $V(\Phi^2)$ designed to trigger spontaneous Lorentz symmetry breaking in the system. We review the general derivation of the Goldstone theorem and we study the propagation of the corresponding Goldstone modes starting from the linearized version of the model. We use two different approaches to discuss the symmetry breaking: (1) in the first case we start from an arbitrary potential having a minimum at $\Phi_\mu = C_\mu$ and we study the excitations ϕ_μ around the minimum which contain the resulting Goldstone modes. (2) in the second approach we freeze the non Goldstone modes by restricting the field Φ_μ to the orbit of the vacuum via a Lagrange multiplier. The case of a bumblebee model in $(1+1)$ dimensions is reviewed for comparison purposes.