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Nonlinear interactions in relativistic and quantum physics

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Linear physics is “easy” to solve. Whether in a purely quantum mechanical system, or when considering quantum fields, quadratic (i.e., linear) Hamiltonians give rise to well known and established phenomena. Exotic and trademark phenomena in quantum field theory in curved spacetime, such as the Hawking effect and the Unruh effect, are all consequences of linear physics.

Most physics is, in general, nonlinear. Nonlinearities appear in the most diverse areas of physics and have, so far, been treated with ad-hoc (and often numerical) methods.
Here we present a novel approach to study nonlinearities with analytical tools. We have already successfully applied these tools to solve problems of interest in opto-mechanical systems, which are now being explored as potential probes for ultra-precise measurements of gravitational fields and curvature.
Our results can be extended to Hamiltonians of arbitrary form, therefore potentially offering a tool to explore nonlinear dynamics of any kind.
Applications and outlook are also discussed.

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