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Non-perturbative modelling of quadratically coupled detectors in QFT

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QFT models involving detectors are usually modelled perturbatively out of necessity, however, there are certain situations when non-perturbative methods can be used. When the detector is a finite dimensional qudit, non-perturbative modelling is possible if the detector interacts suddenly and very quickly (δ-switching) or if the detector is degenerate (zero energy gap). When the detector couples linearly to the field, numerical evaluation of the model requires an understanding of the Lie Group of (Glauber) coherent states and linear displacement operators, including the exact evaluation of the inner product between two different coherent states. Fortunately, coherent states are frequently used in quantum optics and their algebraic properties are well known. When the detector couples quadratically to the field, we require an understanding of the Lie Group of quadratic displacement operators. Whilst these operators are used in quantum optics, there are some gaps in knowledge, specifically the exact evaluation (including complex phase) of the inner product between two different quadratically displaced states. In this talk I will be introducing a technique for evaluating the inner product between two different quadratically displaced states. I shall then use this technique to model two example scenarios relevant to RQI, 1) how does the excitation probability of a detector change by the presence of another detector in its past? (Fermi problem); 2) What is the energy density of a scalar field after a detector interaction and measurement? These questions have been answered for linear detectors, although they have not previously been solved for quadratic detectors. This tool is expected to become increasingly useful in optomechanical and superconducting analogue gravity modelling. ArXiv: 2504.11799

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