Locally Acting Mirror Hamiltonians

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Photons, i.e. the basic energy quanta of monochromatic waves, are highly non-localised and occupy all available space in one dimension. This non-local property can complicate the modelling of the quantised electromagnetic field in the presence of optical elements that are local objects. Therefore, in this paper, we take an alternative approach and quantise the electromagnetic field in position space [1-4]. Taking into account the negative- and the positive-frequency solutions of Maxwell's equations, as illustrated in Fig. 1, we construct annihilation operators for highly-localised field excitations with bosonic commutator relations. These provide natural building blocks of wave packets of light and enable us to construct locally-acting interaction Hamiltonians for two-sided semi-transparent mirrors.

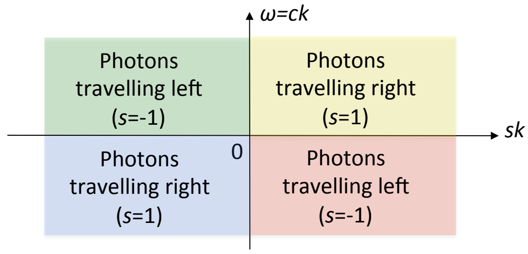

Figure 1: In this paper, we effectively double the usual Hilbert space of the quantised one-dimensional EM field and identify its basic energy quanta by their direction of motion $s = \pm 1$, their polarisation $\lambda = \mathsf{H}, \mathsf{V}$ and their frequency $\omega = ck$ which can be both positive and negative. In other words, as we shall see below, the eigenvalues $\hbar\omega$ of the Hamiltonian, which generates the dynamics of light, can be negative as well as positive. Using this notation, the always positive energy and corresponding classical wave number of a photon equal $\hbar c|k|$ and sk, respectively

References

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[3] D Hodgson, J Southall, R Purdy and A. Beige, submitted

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