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Non-unitary Scattering and Capture. I. Hilbert Space Theory

E. B. Davies
St. John's College, Oxford OX1 3JP, UK

Abstract. By carrying out a general analysis of properties of the wave operators for the non-unitary scattering theory which arises in connection with the use of complex "optical" potentials in nuclear scattering and elsewhere, we clarify some puzzling differences between two recent approaches to this subject.

1. Introduction

In two recent papers [1, 12] B. Simon and the author have discussed scattering problems for one-parameter contraction semigroups on Hilbert space. These semigroups arise in the complex "optical" potential approach to scattering theory of multiparticle systems, in which the effect of "external" channels is taken into account in a phenomenological manner by including absorptive or decay terms in the interaction. The virtue of the model is that it eliminates a large number of degrees of freedom and hence leaves one with a more analytically tractable problem.

Another virtue of this approach is that one may easily incorporate into it effects of interactions with the electromagnetic field. In standard multiparticle scattering theory such common phenomena as the capture of a neutron by a nucleus cannot occur, because the compound nucleus which is formed is unstable, and only becomes stable upon the emission of γ-radiation. On the other hand we shall show in [2] that in an appropriate quantum dynamical semigroup model of neutron scattering capture may indeed occur.

We start by assuming that the free evolution is described by a self-adjoint Hamiltonian H_0 on the Hilbert space $\mathscr{H}$, and that the interaction Hamiltonian is $H = H_0 + V$, where the perturbation V is not self-adjoint. The following is the first of a series of hypotheses, each of which will be assumed to hold after its formulation, without further mention.

Hypothesis A. The Hamiltonian H_0 is semi-bounded. Also $V = V_1 - iV_0$ where the self-adjoint operators V_0 and V_1 have $\mathrm{Dom}(V_i) \supseteq \mathrm{Dom}(H_0)$, and $V_0 \geqq 0$. Finally, V_i are relatively compact with respect to H_0.

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