Commun. math. Phys. 43, 161—170 (1975)

Photoionisation of Atoms and Möller Operators

Philippe Combe
Université d'Aix-Marseille II, UER Scientifique de Luminy et Centre de Physique Théorique, CNRS, Marseille, France

Eric Mourre and Jean-Louis Richard
Centre de Physique Théorique, CNRS, Marseille, France

Received January 22, 1975

Abstract. The motion of an hydrogenoïd atom in a laser field is usually given by the time-dependent hamiltonian $\mathrm{H}(t)=[\boldsymbol{p}-\boldsymbol{A}(t)]^2/2+\mathrm{V}(r)$ where $\mathrm{V}(r)$ is the atomic potential while $\boldsymbol{A}(t)$ is to be connected with the laser field. The existence and unicity for the Cauchy problem of the solutions of the corresponding Schrödinger equation are established under mild conditions on $\boldsymbol{A}(t)$ and $\mathrm{V}(r)$. The existence of Möller operators is investigated in two cases, namely, when the laser field is a function of time only and when it vanishes asymptotically in time. Special attention is paid for the Coulomb case for which a "distorted" Möller operator is derived. Finally, when the laser field vanishes as $t\to\infty$, the photoionisation probability is properly defined by means of the Möller operator

$$\Omega(\mathrm{H}_{\mathrm{A}t},\mathrm{H})=\operatorname*{s-lim}_{t\to\infty} U_{\mathrm{A}t}(t)^{-1}U(t)\,,$$

where $U(t)$ is the evolution operator for the system while $U_{\mathrm{A}t}(t)$ is the evolution operator for the atom.

I. Introduction

The multiphotoionisation of hydrogenoïd or rare gaz atoms by a laser beam has received special attention both experimentally [1] and theoretically [2]. The availability of higher and higher intense beams leads us to abandon the perturbative expansion approach. Other kinds of approximation have been proposed [3] in the framework of a semi-classical treatment in which the photon beam is regarded as a classical external field. However, the non perturbative approximations are motivated by arguments based on pure classical mechanics. We then feel it necessary to have a global analysis of the Schrödinger equation used to describe the multiphotoionisation process. This is the aim of this note.

It is physically reasonable to assume that the system under consideration can be reduced to the interaction of an electron with a central potential (the atomic potential seen by the electron) and with the external radiation field. More precisely the hamiltonian to be considered will be written as

$$\mathrm{H}(t)=\tfrac{1}{2}[\boldsymbol{p}-\boldsymbol{A}(t)]^2+\mathrm{V}$$

when expressed in atomic units, where V denotes the central potential while $\boldsymbol{A}(t)$ is the electromagnetic potential for the radiation field.

In Section II, one proves the existence of solutions of the Schrödinger equation and their unicity for the Cauchy problem [4], under rather mild conditions on V and $\boldsymbol{A}(t)$.