SPIN POLARIZATION BY INELASTIC ELECTRON-ATOM COLLISIONS

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Measurements of electron spin polarization resulting from inelastic electron scattering by mercury (excitation of the 6^1P_1 state; 6.7-eV energy loss) are reported. The angular dependence of the polarization has been measured for incident energies of 25, 30, 50, and 180 eV.

Electron spin polarization due to elastic scattering is one of the topics of atomic physics where there have been very recent advances.[1] But so far there has been neither theoretical nor experimental work on the problem of electron polarization in inelastic scattering although the importance of this point has been occasionally emphasized.[1,2] It is the purpose of this Letter to present first experimental results on this problem.

The spin polarization $P(\theta)$ of electrons after excitation of the 6^1P_1 state of mercury has been studied in the angular range $20° \leq \theta \leq 135°$. The apparatus is similar to that described in an earlier paper,[3] the main difference being a differential energy analyzer in between the scattering chamber and the Mott detector.

There were two main difficulties in the experiment: Since the inelastic cross section at larger angles is rather small, the intensity in the inelastic channel was low. According to the early measurements of Mohr and Nicoll[4] which have been recently repeated by Eitel[5] and Gronemeier,[6] the inelastic cross sections are by one to two orders of magnitude smaller than the elastic ones. This together with the fact that elastic and inelastic cross sections have very similar shapes at many energies causes the second difficulty: One has to make sure by elaborate measurements that the observed results are not due to double (or plural) scattering, where one of the processes is a large-angle deflection. At each energy the reliability of the results had to be checked by systematic reduction of the target density.

Figure 1 shows two examples of inelastic polarization curves together with the corresponding elastic polarization curves. Elastic and inelastic results resemble each other closely at 180 eV, whereas at 25 eV there is no similarity at all. The measurements, which are not presented here, show that the similarity extends down to 50 eV, whereas at 30 eV elastic and inelastic curves differ considerably. The cross sections show a similar behavior, as has been known for a long time.[4]

The polarization measurements confirm the simple model which Massey and Mohr[8] and Massey and Burhop[9] used to describe inelastic scattering: The inelastically scattered electron observed at large angles has undergone a small-angle deflection in exciting the atom and large-angle elastic scattering in the field of the same atom. The experimental results are compatible with the fact that it is the latter process which is responsible for the polarization. When the energy loss can no longer be considered small compared with the incident energy the simple model

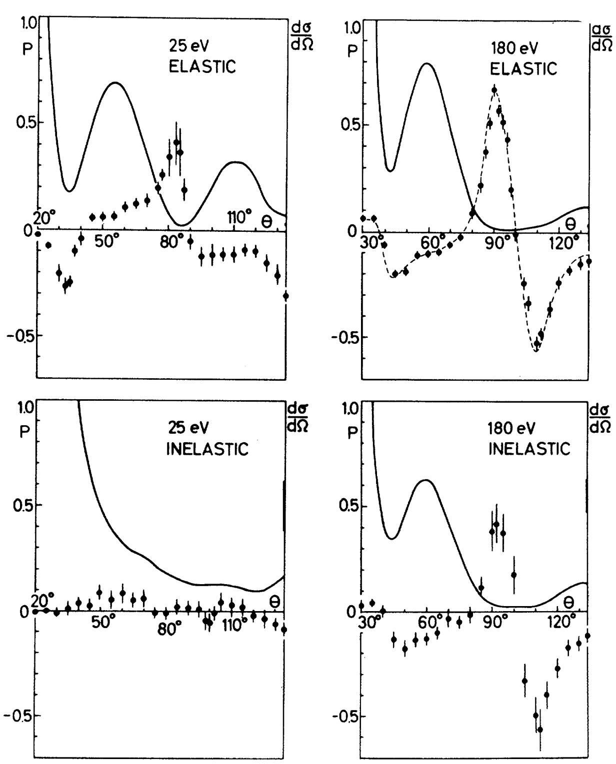

FIG. 1. Comparison of results for elastic and inelastic scattering (6.7-eV energy loss) from mercury. Points, experimental polarization P; dashed curve, theoretical polarization P (Ref. 7); solid curve, experimental cross section $d\sigma/d\Omega$ (arbitrary units).

breaks down, and neither cross sections nor polarization curves for inelastic and elastic scattering are similar.

Quantitative calculations of the polarization effects, taking into account the coupling between elastic and inelastic channels,[10] in conjunction with the present measurements would yield detailed information on the inelastic scattering process and are highly desirable.

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CONTINUITY OF THE PRESSURE AS A FUNCTION OF THE DENSITY FOR SOME QUANTUM SYSTEMS

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We prove that for quantum systems with hard-core or repulsive interactions, the pressure is a continuous function of the density, for Boltzmann particles and for bosons at low density.

An important problem in a rigorous formulation of equilibrium statistical mechanics is the problem of the existence of the so-called thermodynamic limit or infinite-volume limit. Knowing the interactions of the particles at the microscopic level, one constructs the partition function for a finite system via the Gibbs distribution. The thermodynamic quantities that describe equilibrium, such as the free energy per unit volume or the pressure, are then obtained from the partition function by a suitable limiting process in which the system becomes infinite. For instance, in the grand canonical formalism, which we shall consider exclusively here, the pressure p is defined as a function of the inverse temperature β and the chemical potential μ by

$$\beta p = \lim_{\Lambda\to\infty} \beta p_\Lambda = \lim_{\Lambda\to\infty} V^{-1}\ln Z, \tag{1}$$

where Z is the grand partition function of a system in equilibrium at (β, μ), enclosed in a box Λ of finite volume V. The density ρ is then defined by $\rho = dp/d\mu$. One is then faced with the problems of proving that the limit (1) exists, and that the function $p(\beta, \mu)$ thereby obtained has reasonable properties. Of special interest is the property that p, considered as a function of ρ, after elimination of μ between p and $\rho = dp/d\mu$, should be continuous. The existence problem of the limit (1) has received extensive treatment in the last ten years, both for classical and quantum systems, and is by now well understood.[1] The continuity of $p(\rho)$, however, has been proved only for classical systems.[1,2] In the present paper, we extend this proof to some quantum systems with hard-core interactions or purely repulsive interactions. The proof applies for all values of (β, μ) for systems obeying Boltzman statistics, and for all β and all $\mu < -2B$ for systems of bosons, where B is a real constant depending only on the interactions.

We consider a system of identical particles in ν-dimensional Euclidean space R^ν, interacting through a two-body potential Φ satisfying the following properties: There exist real finite constants a, c, and B with $0 < a \leq c$ and $B \geq 0$, such that:

(A) Φ has a hard core of diameter a, i.e., $\Phi(x) = +\infty$ for $|x| \leq a$; $\Phi(x)$ is continuous for $|x| > a$; Φ is absolutely integrable for $|x| \geq c$, i.e.,

$$\int_{|x|\geq c} |\Phi(x)|\,dx < +\infty.$$

Note that (A) allows an arbitrary growth of Φ in the vicinity of the hard core. Spherical symmetry is not assumed, except for the core.

(B) For any finite family $(x_0, \cdots, x_n)$ of $n+1$