CROSS SECTIONS FOR SLOW ELECTRON SCATTERING BY CADMIUM ATOMS

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Total electron scattering cross sections for cadmium atoms and the ionization and excitation efficiency for the lower metastable levels at the same scattering geometry and efficiency of the detecting apparatus is presented, providing their absolute normalization.

Introduction

Cadmium, with its complex electronic structure, represents an interesting target for studying a large variety of collision processes. It has been the subject of a number of photon [1] and electron [2] impact studies, however, the total electron scattering cross-section remains not studied up to date. For the second group of elements, there are experimental measurements for the electron-impact integral elastic cross-section and for inelastic cross sections in the case of Mg and Ba atoms [3,4], and total cross-section measurements for Ca, Sr and Ba atoms [5].

Using the advantages of electron spectroscopy in the case of electron-cadmium atom collisions we are able to resolve more precisely the structure in the energy behaviour of the total cross-section.

The method of measurements and apparatus

We report here the results of the studies on the absolute total cross-section for electron-cadmium atom collision. In our investigation, we focus first of all on the development of the method for measuring the low-energy elastic and inelastic electron scattering by cadmium atoms and determining the absolute cross sections. Therefore we measure the ionization efficiency and the total cross-section at the constant scattering geometry. Since the valid signals were measured without any changes, the errors connected with the determination of the detecting system sensitivity were eliminated.

In the present work, a crossed electron and atomic beams scattering geometry was employed. The electron spectrometer used by us comprises two serially mounted hypocycloidal electron energy analysers [6], the first being the monochromator and the second being the scattered electron analyser.

In Fig.1 the schematic layout of the hypocycloidal electron spectrometer (HES) is shown. It comprises an electron monochromator (electrodes K, A1, A2, A3, B1, B2), a collision chamber (electrodes A4), an electron analyser (electrodes A5, A6, B3, B4) and primary (electrodes A7, F1) and scattered (A7, F2) electron detectors. Electrons, emitted by the oxide cathode K, enter the monochromator drift region between two electrodes , A2 and A3. The transverse electric field in the monochromator (and in analyser too) is produced by cylindrical capacitors B1-B2 (or B3-B4). Electrons accelerated into the collision chamber A4 up to E_{in} energy are crossed there with the cadmium atomic beam and then enter the analyser drift region between electrodes A5-A6. The electrode A7 together with the Faraday cup F1 detect the primary electron beam and suppress background caused by electrons scattered from the surface. The inelastically scattered electrons are deflected by the electron analyser into the slit in the electrode A7, collected by the second Faraday cup F2 and measured by a sensitive electrometer. All the spectrometer is immersed into the homogenous magnetic field produced by a pair of Helmholtz coils.

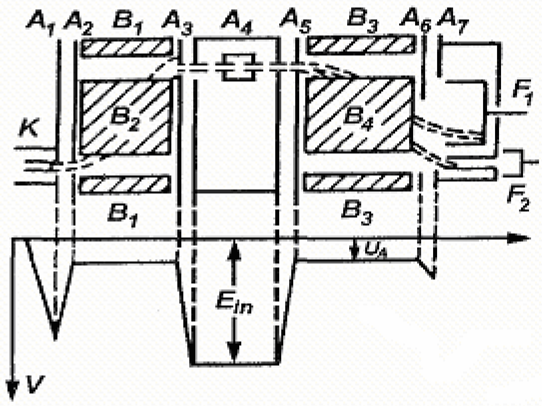

Fig.1. The hypocycloidal electron spectrometer and the typical working potentials

In the case of the measurement of ionization efficiency the electron beam after monochromatization entered the collision chamber, intersected the atomic beam, the ions were extracted using a special plate with negative potential and detected by a digital nanoamperemeter. In this case the primary electrons passed second hypocycloidal analyser without deflection and were collected by the Faraday cup F1.

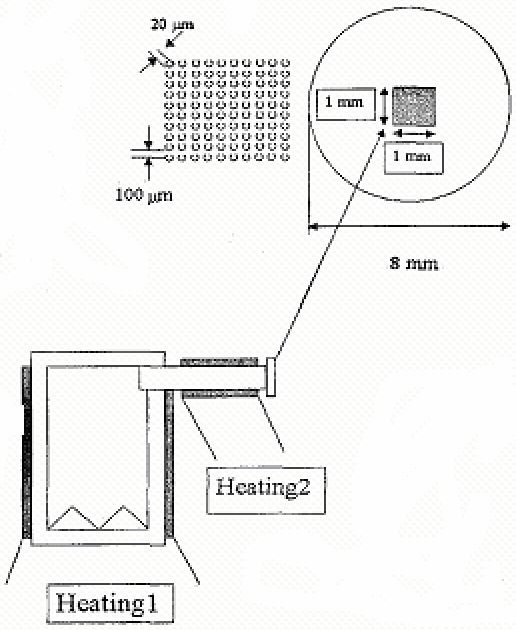

Fig.2. The atomic beam source with the microchannel exit.

When measuring the total electron scattering cross-section for cadmium atoms, the scattering geometry was the same as described above, but all the scattered electrons were collected by the collision chamber electrodes and detected by a digital nanoamperemeter.

The cadmium atom beam was produced using a compact effusion source manufactured from stainless steel with an microchannel exit (see Fig.2) to minimize the angular divergency of the beam. The temperature of the microchannel plate was kept about 50 K higher than that of the metal vapour in the heated reservoir. This atomic beam source enabled us to produce an atomic beam with a concentration of two order higher than that in the case of a standard effusion source.

Results and discussion

The well-known [7] absolute ionization cross-section σ_i was used to calibrate the electron-cadmium total cross-section using the relation

$$\sigma_x = \frac{i_x}{I_x}\frac{I_i}{i_i}\sigma_i, \quad (1)$$

where i_x is the scattered electron current, I_x is the incident electron current when measuring the total cross-section, i_i - the measured ion current and I_i is the incident electron current in measuring the ionization cross-section.

In Fig.3 the measured ionization cross-section normalized to resuts of [7] is shown. The energy behavior of this curve agrees well with the results of earlier work [8] , but we not observed the feature at the energy 11.9 eV resolved in the experiment of [9].

Fig.4 shows the energy dependence of the total electron-cadmium atom cross-section in the incident electron energy range 0-7 eV. This curve demonstrates a sufficiently broad feature near 4 eV caused by the 5^3P_j metastable states of cadmium atom. There is a Ramsauer minimum near 0.5 eV. It follows from [2], that close to ~0.3 eV a resonance feature must be observed modifying this minimum in the total electron-cadmium atom cross-section.

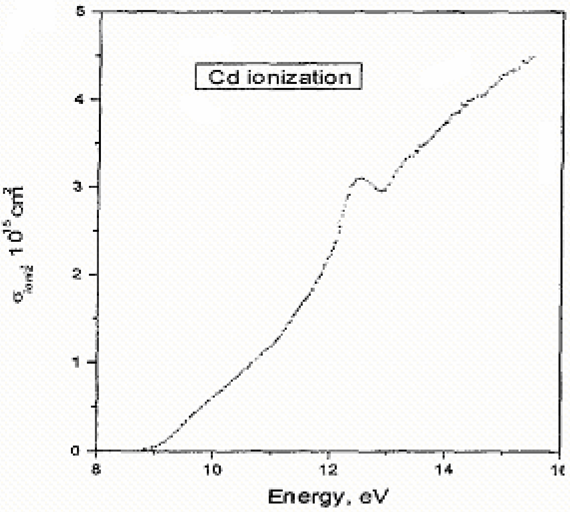

Fig.3. The Cd ionization cross-section

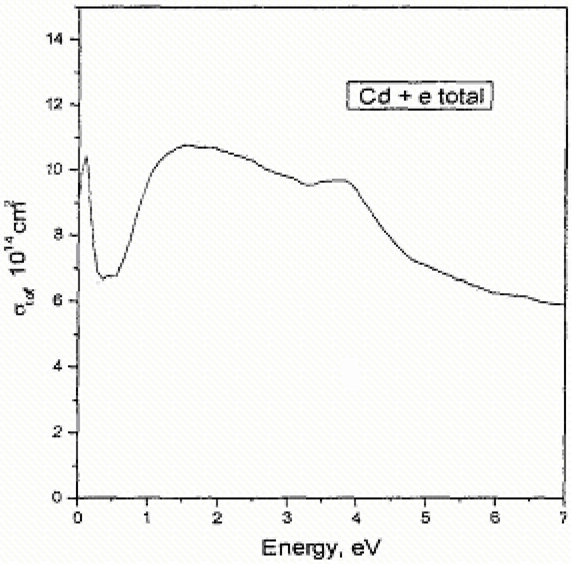

Fig.4. The e+Cd total cross-section

Conclusions

The electron spectroscopy method described in this paper has yielded a complete technique for absolute cross-section measurements of electron-metal atom collisions and enabled us to resolve the fine structure of the measured energy dependences. The obtained total cross section enable one to extract by fitting its low-energy behavior, the scattering length and the dipole polarizability of the cadmium atom [10].

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ПЕРЕРІЗИ РОЗСІЮВАННЯ ПОВІЛЬНИХ ЕЛЕКТРОНІВ АТОМАМИ КАДМІЮ

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Представлено результати вимірів повного перерізу розсіювання повільних електронів атомами кадмію, переріз іонізації та збудження нижніх метастабільних рівнів атома, отриманих в однакових експериментальних умовах, при постійній геометрії розсіювання та ефективності реєструючої апаратури, що дозволило здійснити їх абсолютне нормування.