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TEST OF RANDOMNESS OF BINARY ELECTRON-ATOM COLLISION EVENTS

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1. INTRODUCTION

The atomic events are characterized by randomness in time, in space, direction, etc. This fact is intuitively acceptable to experimantalist who has measured an effective cross section by extensively used single electron counting technique. Quantitative test of the randomness in the time is carried out by statistical method of Pearson's correlation coefficient

$$r = \Delta t't''/\Delta t'\Delta t'', \tag{1}$$

where $\Delta t't''$ is the mean product of the deviations, and $\Delta t'$ and $\Delta t''$ are the root mean square deviations of t' and t", respectively. In this analysis (t',t") is the pair of time intervals which separate an atomic event from the previous one and from the following one.

Examples of the test of randomness can be found in literature [1], carried out by Rutherford for α-particle emission, and by Mayer and Gerlach for photoelectron emission events from metal exposed to ultraviolet light. But, to our knowledge, there is no example of test of randomness in the time of the electron scattering in binary electron-atom collisions.

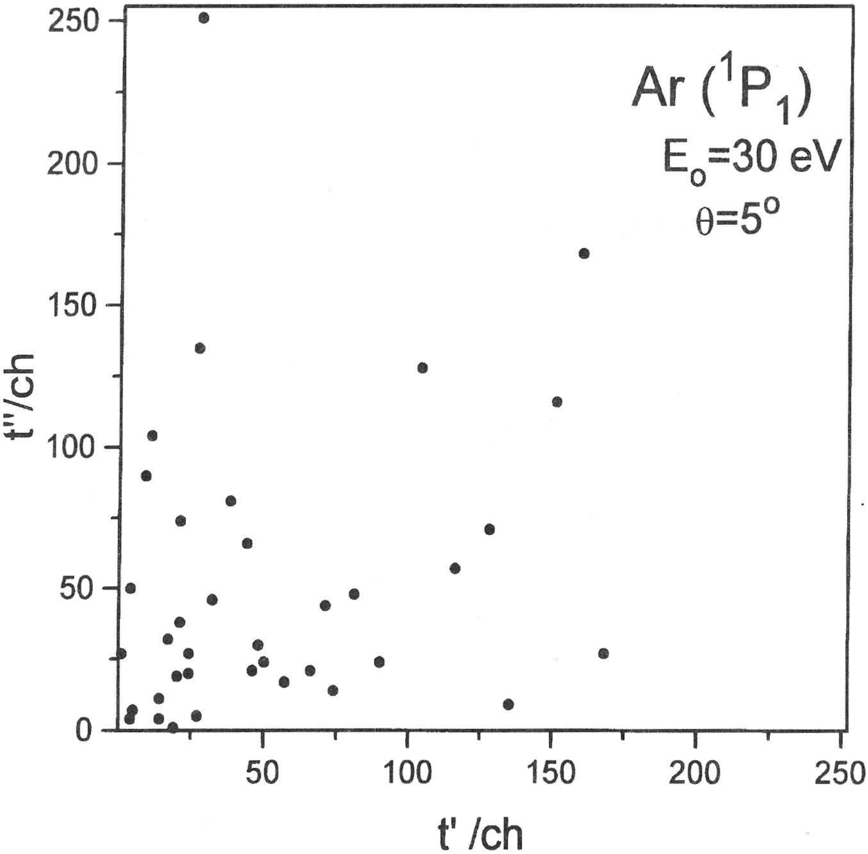

Figure 1. Correlation diagram of time intervals t' and t", preceding and following the electron-atom collision signal. The atomic event is electron impact excitation of Ar from the ground state to $4s'[1/2]_1$ ($^1P_1$) state. The impact energy is E_o=30 eV, and the scattering angle is 5 deg. (Units are the time-per-channel, 10 ms approximately.)

2. EXPERIMENTAL

The measurements of angular distributions of electrons scattered elastically or inelastically on an atom has been the subject of our interest for a long time. Our choice is argon-gas-target because the results of electron scattering on this atom in the form analogous to the diffraction picture of the light scattered by small spheres was the first strong proof of wave properties of the electron in binary electron-atom collisions [2]. The model of the electron in binary collisions is a plane wave as a good approximation of a wave packet if incident electron beam is monoenergetic. High energy resolution is desired also to resolve scattered electrons from a single atomic process.

Our electron spectrometer described earlier [3], exceeds 40 meV overall resolution. Existing modes of operation of the spectrometer are with no constant energies: in the energy-loss mode the final atomic state changes, and in the impact-energy mode the incident electron energy is not constant. We performed stationary experimental conditions by "impact-energy" mode disconnecting ramp of multichannel analyser (Tracor Northern TN-1705) for changing the energy, and using this ramp for the time scale calibration. In this way, a time interval is divided into 1023 channels, that is the same number of separate experiments.

We recorded the signal as a result of detection of electrons scattered after inelastic electron - single atom collision (excitation of Ar atom from the ground state to $4s'[1/2]_1$ ($^1P_1$) state). The incident electron energy was 30 eV, and the scattering angle was 5°.

The Pearson's correlation coefficient of r=0.091, clearly shows randomness of the atomic events investigated through the strength of correlation. Another way of presentation the result of the test, through t'=t'(t") correlation diagram, shows diffusion of (t',t") points (Fig.1). It is the proof that the strength of correlation is week, and no functional form of the correlation.

The test of randomness presented here is of fundamental interest for high school Atomic Physics education. Also, this test enables to find some experimental imperfections as relatively large dead-time of the detector and any noise which is not random-walk. Detailes of the probability distribution will be presented on the conference.

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