# Oscillation of fast ions interacting with a thin amorphous dielectric film

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(Submitted July 2, 1976)
Pis'ma Zh. Eksp. Teor. Fiz. **24**, No. 3, 161–163 (5 August 1976)

It is established that the $Cf^{252}$ fission fragments entering in a thin collodion film at a small angle move along an oscillating trajectory that passes partly through the air near the film and partly in the film material. In many cases the oscillating fragment is stopped in the film material and a unique "drawing" of the ion into the film takes place.

PACS numbers: 29.70.Gn

In an experimental investigation of the regularities governing the interaction of the fragments from spontaneous fission of $Cf^{252}$ nuclei (fast ions with initial energy $\epsilon_0 \approx 8\times 10^7$ eV, charge $g/e \approx 20$, and mass $M \approx 2\times 10^{-22}$ g) with massive plates and with thin films of collodion, we have observed some distinctive pecularities of this interaction, consisting in the following:

1. Fragments from a flat diffuse source with an emission solid angle $2\pi$, on entering the substance at a small grazing angle $\psi$ between the direction of the momentum $p_0$ and the collodion surface, produce surface tracks ($S$ tracks), [1] the number and length of which in films $\lambda \approx (6-8)\times 10^{-6}$ cm thick turn out to be much larger than in bulky plates. The corresponding track-length distribution functions are shown in Fig. 1.

2. Intermittent tracks are observed in collodion. A detailed electron-microscopic investigation of these tracks indicates that the fragment that produces them penetrates the film several times, moving along an oscillating trajectory that lies in part in air near the film and in part in the film material. Convincing proof of the oscillating character of the trajectories provided by the structure of the points where the fragment enters and leaves the films, where

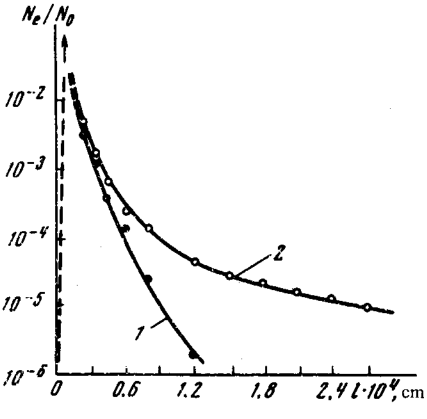

FIG. 1. Distribution functions of the tracks in length ($l$) in a bulky plate (1) and a thin film of collodion (2).

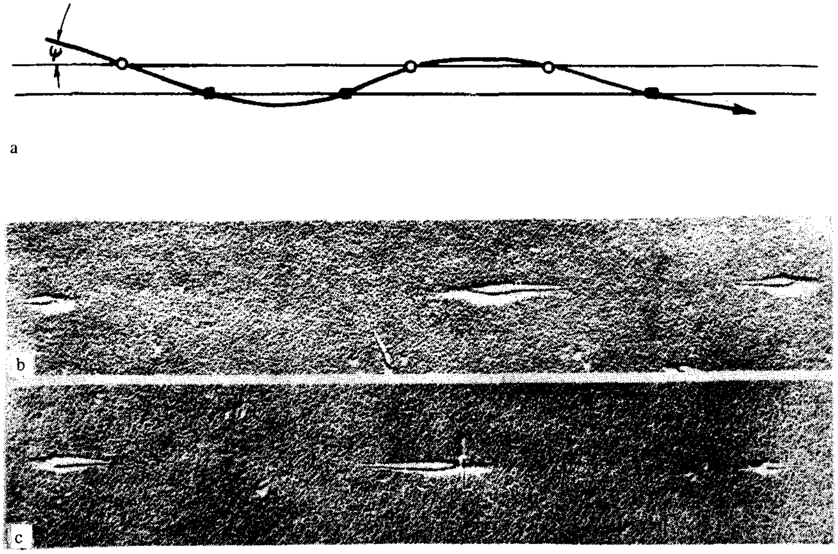

FIG. 2. Typical oscillating fragment trajectories: a) diagram of trajectory, b) from the bombarding site (the open circles on the plot), magnification 45 000×, *c*) on the site opposite to the bombardment (rectangles on the plot); 45 000×.

"electrostatic scratching" of the surface is observed, [2] which produces on the surface oppositely directed "forks" lying on one straight line (Fig. 2). We have also verified the oscillatory character of the trajectory in experiments in which the film was bilaterally displaced in the region of the intermittent track. The possible suspicion that the oscillating trajectory is the consequence of the waviness of the film was refuted in experiments in which intersecting trajectories of two fragments were observed. It turned out that in the same section of the film one fragment traveled above its surface and the other under its surface, something impossible if the fragment trajectories are straight lines.

3. In many cases the oscillating fragment is stopped in final analysis in the film material and a unique "dragging" of the ion into the film takes place. A situation can occur, however, in which the fragment, after crossing the film two or three times, does not return to the film and being scattered by the atom in the film through a considerable degree, moves away from the film.

We note that since we have experimented with an amorphous dielectric, the described phenomena are not connected in any way with orientation effects due to the presence of long-range order in the positions of the atoms of the dielectric.

The possible cause of the observed phenomena consists in the action exerted on the fast ion by the image force, which as applied to boundaries between two dielectrics with dielectric constants $\epsilon_1$ and $\epsilon_2$ is given by the formula $F = [(\epsilon_1 - \epsilon_2)/(\epsilon_1 + \epsilon_2)](q^2/x)$, where $x$ is the distance from the ion to the boundary of the dielectric. It is easily seen that since the dielectric constant of the collodion is larger than that of air, the force $F$ will decelerate a fragment moving in the film and will attract to the boundary a fragment moving in air, that is, it will return it to the film. Obviously, the force $F$ quenches in this case the momentum component normal to the dielectric interface, which is proportional to $p_0\psi$. We note that the foregoing estimate for $F$ can be used only if the inequality $a < x \ll \lambda$ is satisfied, where $a$ is the interatomic distance. We note that if the image force is taken into account the difference between the track-length distribution functions in bulky plates and in thin films (Fig. 1) can be qualitatively explained in natural fashion by the fact that in thick plates the tracks are not repelled by the second boundary.

As pointed by A. F. Andreev, it is not excluded that the force returning the fragment to the film is not of static but of dynamic origin and is due to polarization of the dielectric medium by the moving fragment.

In conclusion, we call attention to the fact that the problem of the stability of motion along a gap in a dielectric should be considered with allowance for the possibility of the "drawing" of the ion into the dielectric.

We are grateful to A. F. Andreev, M. I. Kaganov, and I. M. Lifshiftz for a useful discussion of the effect.

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[2] Ya. E. Geguzin and I. V. Vorob'eva, Dokl. Akad. Nauk SSSR **208**, 584 (1973) [Sov. Phys. Dokl. **18**, 64 (1973)].