Experimental study of environment ionization in the zone of a periodic discharge in a flow of liquid (PDFL)

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Abstract. The study of the ionized environment in the area surrounding PDFL has showed the presence of visible plasmoids moving in the horizontal plane. The study of traces on the X-ray film made it possible to detect a significant number of traces of an identical shape and size that look like the "birds" which were found earlier in other facilities. A preliminary analysis has been carried out for their identification, which led to a conclusion about the nature of these formations, in particular, their identity with the Dirac monopole (or similar object) having a "tail" and "wings" formed by a flow of electrons from the surroundings.

1. Introduction
From the very beginning of work with PDFL in 1995-1996 [1], the appearance of unusual pinch plasmoids in the zone adjacent to the discharge was noted, Fig. 1, 2, 3. In particular, there were the luminous filaments up to a few centimeters long, having an increased luminosity at the ends. In some cases, these filaments "hung" in the air, in other cases one of the "filament" ends extended to the grounded substrate, and the overall pattern resembled a "firework". Luminous long-lived plasmoids were observed in experiments in the following years [2], and their distance from the discharge could be several centimeters or more, which excludes the possibility of explaining their appearance by the presence of liquid droplets sprayed by shock waves. To clarify the nature of these phenomena, the authors have carried out studies to determine the properties of plasma formations in the vicinity of the discharge, in particular, their ionizing ability, namely, the effect on the X-ray film.

Fig.1. A periodic discharge in a flow of liquid. A white circle identifies a plasmoid in the air.
2. Experimental scheme
The experimental scheme is shown in Fig. 4.

Fig. 4. The experimental scheme on the registration of objects in the vicinity of PDFL on the x-ray film. 1 - discharge electrodes; 2 - X-ray film. View from above.

The film was placed at a distance of 19 cm from the axis of the facility (the film size was 18 cm by 24 cm, the films were placed vertically (suspended on special holders in double polyethylene envelopes, opaque to light radiation). The film and envelopes were manufactured by Retina X-Ray XBE Blue-sensitive film, USA.

Several sessions were held, each lasting about 5 minutes. The discharge parameters: voltage on a high-voltage electrode (maximum) is 7.5 kV; duration of current pulses is (2 ÷ 2.5) μs; pulse repetition frequency is ~ 50 Hz; the maximum current in the pulse is up to 5 kA. A detailed description of the facility operation, the measurement technique, the discharge parameters, and the measurement procedure have been repeatedly given earlier [3 ÷ 10].

The film was developed by specialists in an accredited laboratory with industrial equipment designed for this purpose.

2.1 Experimental results
The analysis of traces showed the following.
All films, without exception, showed a large number of the traces of objects which looked like birds (swallows, swifts) with a "wingspread" up to 1 cm (Fig. 5). As a rule, the length of the straight section is from 3 to 5 mm. The most surprising was that in a significant number of cases, dents on the film and even spots were detected in the "head" part of the traces drawing suspicion to thermal effects (as if from burning), which may indicate a thermal impact, but not a mechanical one. There are corresponding bulges on the back side of the film.

No less surprising is the fact that there are similar dents on the back side of the film.

At the same time, no such traces were found on the envelopes (neither external nor internal), which indicates the selective (resonant) nature of the radiation effect on the substance which the film consists of, in particular, on the chemical agents of the photosensitive coating.

The orientation of the position of the "birds" is mostly chaotic (clarification of the systematic general features depending on the parameters of the environment is being carried out at the present time). The total number of such traces at the time of writing the paper was at least a hundred. To exclude the likelihood of the appearance of traces as a result of breaking the conditions for developing or storing the film, a number of control sessions (without a discharge) were carried out, eliminating possible interpretations and suspicions.

3. Photographic recording of objects in the electronic synchrotron "Pakhra"

By coincidence, during the period of the experiments with PDFL the authors had to conduct similar photographic recording sessions on the same film in double envelopes in another facility, namely, in the electron accelerator "Pakhra" (synchrotron with energy up to 1.2 GeV). The experimental scheme is shown in Fig. 6.

![Experimental scheme in the synchrotron of LPI](image)

**Synchrotron**

The objective of the experiment was to determine the "trace" of a bremsstrahlung beam from the conversion target after the passage of electrons through it. The electron beam was then deflected in a magnet with a vertical magnetic field with an induction of up to 1.5 T and a length of about 1 m. The film was located about 1 m from the edge of the magnet. The electrons reaching the film are excluded (the control measurements were conducted).
In the zone of film localization, the presence of magnetic scattering fields from a magnet is estimated to be of the order of $10^{-2}$ T. At the same time, the presence of ionization in the air from an electron beam and a beam of bremsstrahlung (gamma) radiation is recorded.

In the developed photographs, as one would expect, traces of a bremsstrahlung beam were detected. The edges of the magnet can be seen (the gap between the poles of the magnet is $\sim 6$ cm). To the greatest surprise, the same "birds" were found, (Fig. 7), as well as during the experiments with PDFL. Previously, the same facts were not presumably taken into consideration, even if they had occurred. Comparison of experiments in both cases allows us, first of all, to note the similarity of the presence of the following factors:

1. high degree of ionization in the zone of film localization;
2. impulse nature of the effect of ionization factors, namely, pulse duration $\sim (2 \pm 3)$ $\mu$s, repetition frequency $\sim 50$ Hz;
3. magnetic field, directed mainly parallel to the plane of the film.

Fig. 7. Bremsstrahlung tracing. A white circle marks "birds". On the right there is an enlarged image.

Ionization of the air in the PDFL zone is caused both by the expansion of the discharge plasma and by soft X-rays (photoionization is not excluded).

The electromagnetic field is generated in the zone of the LPI accelerator from the accelerator and the output beam and has an amplitude of the same order as the EMP from PDFL.

4. Analysis of the results

As a working hypothesis on the formation of traces, we consider a version of the formation of microobjects in the ionized air, having all the features similar to the Dirac monopole [11] with the accompanying cone-shaped electron trail consisting of Cooper pairs with high penetrating power in the environment. This version is confirmed by the analysis of traces representing in their curved part the cross-section of the conical surface identified with the electron trail, whereas a rectilinear trace can be a monopole track (this version requires clarification). The different orientation of the "birds" can be explained by the dynamics of the objects under consideration having both a magnetic and an electric charge. In non-homogeneous fields in space, when moving both longitudinal and transverse components are affected on them, so that the movement of the leading "center" (monopole or quasimonopole) can be overlapped by the rotation of the electronic trail, which in turn affects the movement of the "monopole-trail" in general.

Currently, other versions are being under consideration, and experiments are being planned to refine the nature and properties of the detected physical objects.

The appearance of monopoles in the zone of PDFL localization can be explained by the nonzero probability of their location in the incoming water. When discharged along the surface of the jet, a part of the water evaporates, decomposes into components (hydrogen, oxygen) and ionizes, which presumably contributes to weakening of the monopole bonds (if they are present there). Since the force lines of the magnetic field have the form of circles symmetrical with regard to the axis of the discharge, the trajectories of the monopoles should look like unfolding flat spirals, at least at the beginning of acceleration (if the monopoles are of the two types - "northern" and "southern" - the
directions of motion are oncoming). As they accelerate, they "build up" electrons from the plasma surrounding the main "body" of the discharge, which contributes to their radial acceleration. If not all, then at least some of these monopoles with a trail of electrons (presumably from Cooper pairs) penetrate through the envelope onto the surface of photographic paper, where they stop, leaving a trace in the form of "birds".

In case of the synchrotron experiment, it can be assumed that the monopoles were originally located on the magnet's surface facing the median plane where the electron beam moves. The "halo" of the electron beam and a significant part of the bremsstrahlung photons fall on these surfaces and can initiate the output of monopoles due to the photoelectric effect and secondary emission, especially since the output is facilitated by the magnetic field of the magnet.

In the pole gap of the magnet, the air is strongly ionized, which facilitates the "accumulation" of monopoles with an electron trail. The dispersion of monopoles with a trail is likely to be in the direction of the motion of photons (by virtue of the law of conservation of momentum). This is also facilitated by charging the envelope with the film up to a positive potential due to the emission of photoelectrons and the difference in the range of electrons and positrons when the substance passes after the formation of electron-positron pairs by a beam of bremsstrahlung photons.

The hypothesis for the presence of magnetic charges in the PDFL area is supported by the formation of pinch discharges, which in their structure are practically similar to the structure of a monopole with a trail of rotating electrons (Fig. 8, 9). A distinctive feature can be the sizes (length up to several millimeters), which, in this case, can be provided by the presence in the base of each pinch of not one but a significant number of monopoles. To find them in a quasistable state in a single cluster, it is sufficient to fulfill the conditions for the charge quasineutrality arising from the presence of not only electrons but also positive ions in the zone of their localization, as well as a certain ratio of the parameters (density, cluster size, etc.). These parameters are determined theoretically on the basis of the gravitational model for estimating the parameters of pinch plasmoids [3].

5. Conclusion
The results obtained in the part related to the detection of traces in the X-ray film in the form of "birds" indicate that we are dealing with a fundamental property of matter, which is confirmed by their detection in the experiments of other authors [12].

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