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IONIZATION DENSITY IN EMULSIONS ENRICHED WITH HYDROGEN

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The ionization loss dependence on the velocity of fast single charged particles in a substance containing one element only is expressed by the well known Bethe-Bloch equation:

$$-\frac{dE}{dx} = \frac{2\pi n e^{y}}{mv^{2}}\left[\mathrm{en}\,\frac{2m\delta^{2}\,W_{max}}{I^{2}(1-\beta^{2})} - 2\beta^{2} - \delta\right] \qquad (1)$$

where "n" is the number of atoms per cm^3, "e" "m" is the electron charge and mass, "I" is the average ionization potential, "W_{max}" is the maximum energy transferred to atomic electrons, "δ" is the correction for the density effect, which is due to polarization of the atoms. When the substance consists of a number of elements, the ionization loss obeys the additivity law.

The theoretical curves calculated for nuclear emulsions on the basis of Sternheimer works[1)] are consistent with the recent experimental data. It was found from these data that the ratio of plateau blob density to that of relativistic minimum (I_{pl}/I_{min}) is 1.10 for NIKFI emulsions[2),3)]. According to ref. 3), the ratio I_{pl}/I_{min} has different magnitudes for the following types of emulsions with similar nuclear compositions:

Kodak	1.105
Ilford G5	1.085
K5	1.120
NIKFI BR	1.080
BM	1.110
Geveart	1.057

This probably indicates that there are some additional factors which affect the formation of the latent image.

According to ref. 1), experiments and theoretical calculations give considerably larger values of the ratio I_{pl}/I_{min} for the main light emulsion elements: H, C, O, N, e.g. for O, $I_{pl}/I_{min} = 1.51$.

Therefore, one may expect an increase in the ratio I_{pl}/I_{min} in emulsions enriched with hydrogen and light nuclei. This rise is also due to the decrease of the factor "δ" in equ. (1), when the emulsion density with constant nucleus composition becomes smaller.

The increase of I_{pl}/I_{min} has been observed in ref. 4), when particles penetrated through polystyrene films with thicknesses less than 0.1 of a AgBr crystal.

In order to investigate this effect, we performed blob density measurements in NIKFI-BR emulsions enriched with H, C, O nuclei. The emulsion pellicles were loaded with ethylene glycol $(CH_2OH)_2$, which allowed us to double the number of hydrogen nuclei, keeping the blob density of relativistic tracks sufficient. In our work this density was found to be 18.5 blobs per 100 μ. The fading of these loaded emulsions did practically not differ from that of the normal NIKFI emulsions; this permits to expose and keep emulsions for a long time. Table I gives the average composition of elements in normal NIKFI emulsions and in the ethylene glycol loaded emulsions used in our experiment.

Table I

	Number of nuclei per $cm^3 . 10^{-22}$	
	NIKFI-BR	loaded
Ag	1.02	0.42
Br	1.02	0.42
H	2.96	5.7
O	1.07	1.91
C	1.39	1.97
N	0.375	0.15

The exposure of the two emulsion samples was performed simultaneously by 2.3 GeV/c protons and π^+-meson beams, separated by an electrostatic separator. The distance between maxima of p and π^+-beams in the same emulsion pellicle was about 16 mm, at a gap of about 5 mm between the beams there were no particles at all.

The number of blobs were counted along the whole length of one of the proton tracks and of one of the π^+-meson tracks. One of the loaded emulsion samples and the control sample were exposed to the internal 5.15 GeV/c proton beam and to 3 GeV/c π^--meson beam at another angle.

The emulsion were kept for 12 hours to reduce the relative regression due to the time difference of 30 minutes between exposures to protons and π^--mesons. Then the emulsions were developed.

The number of blobs was counted on proton and π^--meson tracks in turn over the same area and at the same depth of the pellicle. The calibration was performed by a control pellicle since contamination of particles with smaller momenta was found. For the control (unloaded) emulsion the ratio I_{pl}/I_{min} was taken to be 1.1. The results of our experiment are presented in Table II.

Table II

Emulsion	I_{pl}/I_{min} ratio of blob density for proton and meson tracks	
	momentum P and π 2.3 GeV/c	momentum: P_p = 5.15 GeV/c, P_{π^-} = 3 GeV/c
Normal NIKFI-BR-2	1.02	1.06
Loaded NIKFI-BR-2	1.05 ± 0.01	1.14 ± 0.03

The ratio I_{pl}/I_{min} was calculated according to ref. 1) by using the nuclear composition of the substances from Table I; W_{max} was taken to be 2 KeV, the average ionization potential for normal emulsion was taken equal to 430 eV, for loaded emulsion 310 eV. The magnitude of the ratio I_{pl}/I_{min} was calculated to be 1.16 for normal emulsion and 1.22 for loaded emulsion. It is clear that the observed effect essentially improves the identification of fast particles. It should also be noted that these emulsions had double hydrogen content compared with the normal ones.

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