X-RAY RADIATION IN A POWERFUL PULSED DISCHARGE IN XENON

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Abstract

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PHYSICS

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X-RAY RADIATION IN A POWERFUL PULSED DISCHARGE IN XENON

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As is known ((^1)), a powerful pulsed discharge in a gas, within a certain range of pressures, in addition to an x-ray pulse at the moment of starting, is accompanied by the emission of x-ray quanta at a later stage in the development of the discharge. The moment at which this radiation arises corresponds to the moment at which kinks ("features") appear on the curves of the discharge current and of the voltage on the electrodes of the chamber. In a discharge in light gases, under certain initial conditions, the energy of the x-ray quanta proves to be considerably greater than that which electrons can acquire in traversing the full potential difference applied at the corresponding instant of time to the electrodes of the discharge chamber. Study of this phenomenon, apart from being of independent interest, may prove important for clarifying the nature of cosmic radiation. In the present article we report some results of an investigation of the x-ray radiation of a gas discharge not connected with the start. These results were obtained in studying a discharge in xenon, and also in mixtures of hydrogen and xenon.

The discharge was produced in a porcelain chamber 175 mm in diameter and 1000 mm high. The discharge circuit consisted of a capacitor bank of capacitance (36, F). To measure the voltage between the electrodes of the discharge chamber, an ohmic divider was used. The discharge current was measured with a Rogowski belt with an integrating (RL) circuit. The maximum value of the discharge current, at an initial voltage on the capacitors equal to 40 kV, reached 200 kA.

The experiments were carried out at various initial gas pressures in the range from (5 10^{-3}) to (5 10^{-1}) mm Hg. Spectroscopically pure xenon was used in the work. The choice of xenon was due to its large atomic weight in comparison with hydrogen and to its weak chemical activity. The latter circumstance may be significant because of the possibility of intensive interaction of the heated gas with the wall. A palladium filter was used for purifying the hydrogen. The filling of the discharge chamber with gas was carried out from a calibrated volume, the pressure in which was measured with an oil manometer. This method of filling made it possible to eliminate errors in measuring the initial pressure associated with heating of the walls by preceding discharges.

Fig. 1. Oscillograms of pulses of X-ray radiation and of the voltage on the electrodes. Sweep duration 22 μsec

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To obtain oscillograms of the pulses of x-ray radiation, discharge current, and voltage, a two-beam pulsed oscilloscope of type OK-17 was used. The discharge was initiated at the required instant of time by a pulse that was applied to an electrode mounted in one of the spheres of the discharger. The same pulse was used to start the oscilloscope sweep.

To extract a beam of soft x-ray radiation, which is readily absorbed in the walls of the discharge chamber, holes covered with aluminum foil (7.5,) thick served. The x-ray radiation was registered

with the aid of X-ray film, as well as a scintillation recorder. The method for recording the radiation is described in [1].

Considering the oscillograms of the voltage on the electrodes of the discharge chamber, it is not difficult to see that discharges in hydrogen and xenon, under identical experimental conditions (the initial gas pressure and the charging voltage of the capacitor bank), proceed differently. The features on the current and voltage curves are clearly expressed in those cases when the discharge occurs at low initial pressure in gases with low atomic weight (hydrogen, deuterium, helium). If sharp spikes are observed on the voltage curve during a discharge in hydrogen, then during a discharge in xenon these spikes are absent, although in this case as well the voltage curve differs substantially from a sinusoid. Approximately the same may be said of the discharge-current curves obtained under the indicated conditions.

Fig. 1. Oscillograms of pulses of X-ray radiation and of the voltage on the electrodes. Sweep duration 22 μsec

The oscillograms of X-ray pulses presented in Fig. 1a and b indicate the identical duration of the X-ray pulses during a discharge in hydrogen and during a discharge in xenon. The pulse duration in both cases is approximately 1 μsec; however, the energy of the X-ray radiation during a discharge in hydrogen reaches several hundred kiloelectronvolts, whereas during a discharge in xenon under analogous conditions it does not exceed 10–15 keV. Hard X-ray radiation in a mixture of light and heavy gases was not observed even under conditions when 0.1% xenon by pressure was added to hydrogen at the optimum pressure. The addition of small portions of xenon to hydrogen at such a low pressure that the effect is not yet observed leads to the appearance of soft X-ray radiation at that gas mass which corresponds to the appearance of pulses during a discharge in pure hydrogen.

When considering the oscillograms of X-ray pulses, the absence of a pulse of

Fig. 2

Figure 2: Fig. 2

Fig. 3

Figure 3: Fig. 3

starting X-ray radiation is noteworthy. When oscillographing the pulse of X-ray radiation accompanying a discharge in hydrogen, the scintillation recorder was placed behind lead shielding that completely absorbed the starting X-ray radiation, whose limiting energy was 40 keV. As for the oscillograms of X-ray radiation obtained during a discharge in xenon, despite the fact that in these experiments apparatus was used that recorded quanta of low energy (down to 1 keV), the pulse of starting X-ray radiation at a xenon pressure (P_0 = 2 10^{-2}) mm Hg has such a weak intensity that its amplitude is negligibly small in comparison with the amplitude of the pulse arising at the moment of the feature.

The dependence of the intensity of X-ray radiation on pressure also proves to be substantially different (see Fig. 2). During a discharge in xenon it increases monotonically with decreasing pressure down to the value

$5 \cdot 10^{-3}$ mm Hg, below which breakdown of the gas in the discharge chamber does not occur. In the same figure, for comparison, an analogous dependence obtained for a discharge in hydrogen is given. The sharp difference in the character of the curves shows that the intensity of the X-radiation is not determined by the number of atoms filling the discharge chamber.

On the basis of the theory of inertial compression of the discharge[1], one may assume that one of the principal parameters determining the course of various processes in a powerful pulsed discharge of short duration is the total mass of the gas filling the discharge chamber. To test this assumption, experiments were carried out in which the intensity of the X-radiation was studied for a discharge in mixtures of hydrogen and xenon.

Fig. 2

Fig. 3

The addition of small portions of xenon to hydrogen has no noticeable effect on the intensity of the soft X-radiation if the experiments are carried out at such pressures ($6 \cdot 10^{-2}$ mm Hg) at which a discharge in pure hydrogen is accompanied by X-radiation in the region of the singularity. The situation is different if the initial pressure of hydrogen is low and is, for example, $2 \cdot 10^{-2}$ mm Hg, i.e., under such conditions in which the pulse in the region of the singularity is usually absent. The addition of 1% xenon by pressure at a total mixture pressure of $2 \cdot 10^{-2}$ mm Hg, i.e., under conditions in which the mass of gas is

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[1] M. A. Leontovich, S. M. Osovets, *Atomic Energy*, No. 3, 81 (1956).

increased by approximately a factor of 1.5 while the number of particles remains practically constant, leads to the appearance of an X-ray pulse in the region of the singularity. The amplitude of the X-ray pulse increases as the percentage content of xenon is increased. At the same time the amount of hydrogen was decreased so that the total number of atoms in the discharge chamber remained constant. With a xenon content in the mixture from 5% to 20%, the pulse in the region of the singularity becomes double (Fig. 1b). The reason for the appearance of the double pulse remains unclear to this day. With a further increase in the percentage content of xenon and with the total pressure kept the same, the pulse again assumes its usual form. The dependence of the X-radiation intensity on the total mass of the mixture is shown in Fig. 3. As consideration of this dependence shows, the X-radiation in a discharge in the mixture appears at the same gas mass as in the case of a discharge in pure hydrogen, and this in turn directly indicates the essential role of inertial forces in the development of a powerful gas discharge.

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REFERENCES CITED

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