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E. Gorbunova, A. Ezubchenko, A. Karchevsky, Yu. Muromkin. THE SEPARATION OF ISOTOPES OF NOBLE GASES IN STATIONARY HIGH FREQUENCY DISCHARGE WITH TRAVELLING MAGNETIC FIELD. Journal de Physique Colloques, 1979, 40 (C7), pp.C7-211-C7-212. 10.1051/jphyscol:19797104 . jpa-00219074

HAL Id: jpa-00219074

<https://hal.science/jpa-00219074>

Submitted on 4 Feb 2008

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THE SEPARATION OF ISOTOPES OF NOBLE GASES IN STATIONARY HIGH FREQUENCY DISCHARGE WITH TRAVELLING MAGNETIC FIELD

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Several papers /1,3/ are devoted to research of separation properties of high frequency discharge with travelling magnetic field. It is shown, that the discharge of such a kind is able to separate isotopes and gas mixtures. The separation of gas mixtures is connected in the first of all, with different ionization degree of components. The mechanism of isotope separation has not been cleared up fully yet. As probable causes of isotope separation the processes of barodiffusion and thermodiffusion were pointed out. It is proposed /2/, that the observed isotope separation is connected with thermodiffusion in the neutral plasma component. The reference to the barodiffusion separation mechanism is supported by the fact that in some conditions /1,3/ the coincidence of the measured enrichment coefficient \mathcal{E} with the calculated one according to the formula $\mathcal{E} = \frac{\Delta P}{P} \ln \frac{P_2}{P_1}$, where P_2 and P_1 are pressures on the ends of the discharge chamber, μ is atomic weight. It was expedient to find out how widely such simple regularity of isotope separation effect in plasma takes place. Aiming at this the comparative investigation of isotope separation of three gases, which considerably differ in their atomic weight: xenon, krypton and neon, was carried out.

The scheme of the apparatus is shown in Fig.1. The discharge was exited in the water-cooled quartz chamber (1) 110cm long and with the 6,5cm in diamet-

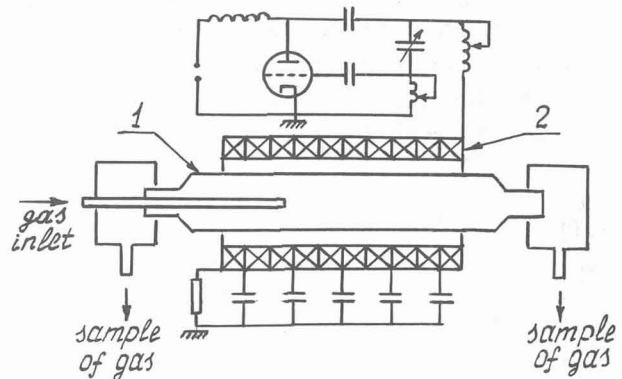


Fig.1. Experimental arrangement. The discharge chamber was placed in the solenoid of the delay line (2), which consisted of 60 cells. The length of the solenoid was 85cm. The phase velocity of the wave $v_{ph} = 5 \div 9 \cdot 10^6$ cm/s, frequency $f = 80 \div 460$ kHz. The amplitude of H_z -component of the magnetic field on the axis of the solenoid at varying the generator frequency in the above mentioned range decreased from 100 to 20 Oe. The power dissipated in the discharge was 2 + 14 kw.

The interaction of the travelling wave with plasma results in the appearance of the pressure difference $\Delta P = P_2 - P_1$ in the closed-ended chamber. The value of ΔP is in a good agreement with the formula: $\Delta P = \frac{W}{S \cdot v_{ph}}$ (W-dissipated power, S - cross-section of the chamber). In the experiments the value of ΔP reached $2,5 \cdot 10^{-1}$ mm Hg. In the discharges with the same value of ΔP the relation

$\frac{P_2}{P_1}$ can differ greatly, depending on the initial pressure P_0 and gas temperature. At constant P_0 the change of the value of $\frac{P_2}{P_1}$ is realized by means of changing the magnitude of the travelling magnetic field and, in accordance, the power dissipated in plasma. The maximum values of $\frac{P_2}{P_1}$, under which the measurements of isotope separation effect were made, were for the discharge in xenon - 140, for the discharge in krypton - 40, for the discharge in neon - 3 (stable discharge in neon was exited only under higher initial pressures than in xenon and krypton). The minimum values of $\frac{P_2}{P_1} \approx 1$ ($P_0 = 2 \text{ mmHg}$).

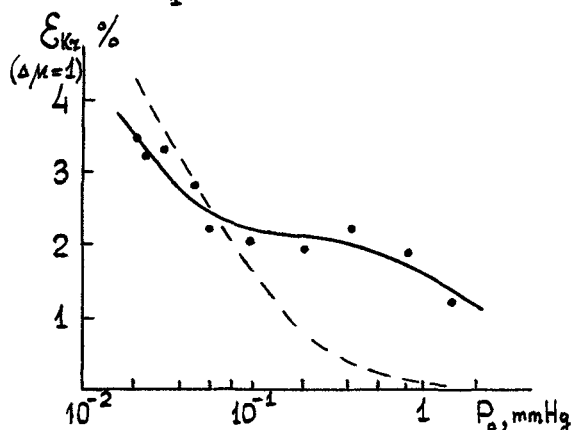


Fig.2. Krypton enrichment coefficient versus initial pressure
 $W = 9 \div 14 \text{ kW}$, $f = 460 \text{ kHz}$

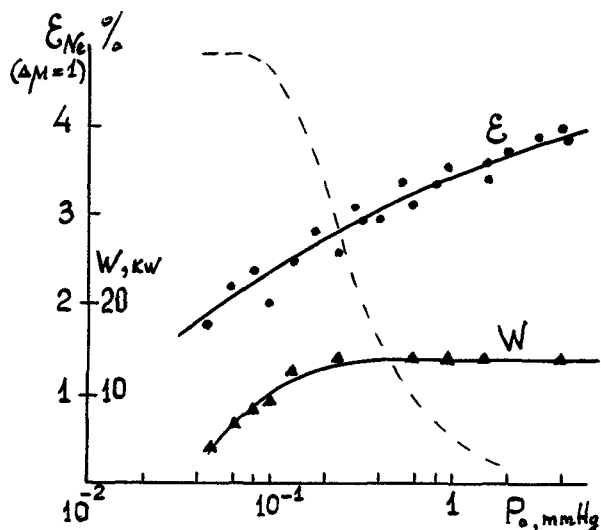


Fig.3. Neon enrichment coefficient and dissipated power versus initial pressure
 $f = 460 \text{ kHz}$

In Fig.2,3 the dependences of enrichment coefficients \mathcal{E} on the initial pressure Kr and Ne are shown. For comparison the values of \mathcal{E} calculated by the formula $\mathcal{E} = \frac{1}{\mu} \ln \frac{P_2}{P_1}$ are shown in the figures in dotted lines (the values of P_2 and P_1 experimentally measured are used). The experiments show, that the quantitative coincidence of the observed isotope separation effect with the effect characteristic of barodiffusion in non-ionized gas, takes place only under some initial pressures. The effect described above can be larger as well as smaller than the barodiffusion one. The last is noticeable in the discharge in neon,

$P_0 < 3 \cdot 10^{-4} \text{ mmHg}$ (Fig.3), and in the discharge in xenon, when the value of $P_1 \leq 1 \cdot 10^{-3} \text{ mmHg}$.

For clearing up the contribution of thermodiffusion in isotope separation effect a cooled quartz tube with the 12mm-diameter was placed on the axis of the discharge. In the tube presence the effect decreased for 30-50 percents. But such experiments do not make it possible to estimate quantitatively the contribution of thermodiffusion. As the circulation of gas in the discharge is caused only by the radial non-uniformity of the acting force, the characteristics of the circulating flows, in the first approach, do not depend on the relatively small diameter tube being on the axis.

The absence of the quantity estimation of thermodiffusion influence hasn't made it possible to distinguish "pure" plasma isotope separation effect.

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