colliding partners, based on the use of the Faddeev equations [8], shows that the angular distribution of the released electron has a maximum at $\theta \sim 0°$. This feature becomes all the more pronounced, the closer the velocity of the released electron is to the velocity of the impinging proton. The dependence of the electron-production cross section on the scattering angle obtained in this investigation for the H^+-Ar pair agrees qualitatively with the calculation results [8].

In collisions of more complicated atomic particles, the electron release may be connected with ionization processes occurring in the quasimolecule produced when the particles come closer together. It is difficult to expect in this case the presence of any preferred electron motion. The almost-isotropic angular distribution observed by us for the electrons released in Ne^+-Ar, Ar^+-Ne, and Ar^+-Ar collisions apparently confirms this assumption.

Deviation from isotropy with decreasing electron energy E_e can be ascribed to the influence of "Coulomb" ionization processes. This influence, however is small in the case considered by us, since the velocities of the colliding ions are much lower than the Bohr velocity.

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[1] W. Mehlhorn, Z. Phys. 160, 247 (1960).
[2] W. Mehlhorn, Z. Phys. 208, 1 (1967).
[3] W. Mehlhorn and D. Stalheim, Z. Phys. 217, 294 (1968).
[4] G. N. Ogurtsov, I. P. Flaks, S. V. Avakyan, and N. V. Fedorenko, ZhETF Pis. Red. 8, 541 (1968) [JETP Lett. 8, 330 (1968)].
[5] G. N. Ogurtsov, I. P. Flaks, and S. V. Avakyan, Zh. Eksp. Teor. Fiz. 57, 27 (1969) [Sov. Phys.-JETP 30, No. 1 (1970)].
[6] G. N. Ogurtsov, I. P. Flaks, and S. V. Avakyan, Zh. Tekh. Fiz. 39, 1293 (1969) [Sov. Phys.-Tech. Phys. 14, (1970)].
[7] D. J. Volz and M. E. Rudd, VI ICP EAC, Cambridge, 1969, p. 410.
[8] J. Macek, VI ICP EAC, Cambridge, 1969, p. 687.

ONE NEW METHOD OF DETERMINING THE DIFFUSION COEFFICIENT IN GAS MIXTURES

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We describe here a new method of determining the coefficient of mutual diffusion in mixtures of two gases from the width of the Mandel'shtam-Brillouin components (MB) in the spectrum of the thermal scattering of light in a mixture of these gases.

As follows from [1], the width of the MB components in the mixture is

$$\delta\nu_{MB} = \frac{\Gamma q^2}{\pi c} \text{ cm}^{-1},$$

$$\Gamma = \frac{1}{2}\{\Gamma_\eta + \Gamma_\chi + \Gamma_D\} =$$

$$= \frac{1}{2}\left\{\frac{4/3\eta + \eta'}{\rho} + \chi\left(\frac{C_P}{C_V} - 1\right) + \frac{Dv^2}{\rho^2(\partial\mu/\partial C)_{P,T}} \times\right.$$

$$\times \left[\left(\frac{\partial \rho}{\partial C}\right)_{P,T} + \frac{K_T}{C_P}\left(\frac{\partial \rho}{\partial T}\right)_{PC}\left(\frac{\partial \mu}{\partial C}\right)_{P,T}\right]^2\Bigg\} . \qquad (1)$$

Here q is the wave vector of the sound wave responsible for the scattering, c is the velocity of light, η and η' are the coefficients of shear and bulk viscosities, respectively, ρ is the density, χ and D the coefficients of temperature conductivity and diffusion, respectively, C_P and C_V are the specific heats at constant pressure and volume, respectively, v is the speed of sound, and $\mu = (\mu_1/m_1) - (\mu_2 m_2)$, where μ_1, μ_2 and m_1, m_2 are the chemical potentials and the masses of the mixture component particles, respectively, C is the concentration, T is the temperature, and k_T the thermodiffusion ratio.

Expression (1) was recently derived also by Mountain and Deutsch [2] in a theory developed by them for the scattering of light in binary liquid solutions. The case of gas mixtures was not discussed in [2].

Estimates show that in liquid and gas mixtures in which the component densities are appreciably different the term containing k_T is small in absolute value compared with $(\partial\rho/\partial C)_{P,T}$ and the diffusion addition to the width of the MB components is determined completely by the quantity $Dv^2(\partial\rho/\partial C)^2_{P,T}/\partial^2(\partial\mu/\partial C)_{P,T}$. In liquid mixtures we have Γ_η, $\Gamma_\chi \gg \Gamma_D$, but in gas mixtures to have $\Gamma_D \gg \Gamma_\eta$, Γ_χ. In the latter case it is possible to determine D from the width of the MB components.

By way of an illustration let us consider the Xe–He mixture with Xe concentration C = 0.1 at a pressure P = 50 atm. Calculation in accordance with the additive scheme yields $\eta \sim 2 \times 10^{-4}$ poise, $\rho \sim 3.75 \times 10^{-2}$ g/cm^3, $\chi \sim 0.004$ cm^2/sec, $C_P/C_V \sim 1.6$, $C_P \sim 4.7 \times 10^7$ erg/g-deg, and $v \sim 6 \times 10^4$ cm/sec. From the known expression [3] for μ we get $(\partial\mu/\partial C)_{P,T} = kT[m_1 C + m_2(1 - C)]/m_1 m_2(1 - C)$, where k is the Boltzmann constant. At $T \sim 300°K$, $m_1 \sim 220 \times 10^{-24}$ g, and $m_2 \sim 6.7 \times 10^{-24}$ g we get $(\partial\mu/\partial C)_{P,T} \sim 8 \times 10^9$ erg.

The thermodiffusion ratio is $k_T = \alpha C(1 - C)$, where α is the thermodiffusion constant. In our example $\alpha \sim 0.4$ [4] and $k_T \sim 36 \times 10^{-3}$. Putting $(\partial\rho/\partial T)_{P,C} \sim 10^{-5}$ g/cm^{3}deg, we find that the term containing k_T is of the order of 6×10^{-5} g/cm^3, which is negligibly small compared with $(\partial\rho/\partial C)_{P,T} = (\rho_1 - \rho_2) \sim 28 \times 10^{-2}$ g/cm^3. Assuming $D \sim 1/P$ we obtain [5] $D \sim 0.014$ cm^2/sec. Putting $\eta' = 0$ [5], we obtain finally $\Gamma_\eta \sim 7 \times 10^{-3}$, $\Gamma_\chi \sim 2.4 \times 10^{-3}$, and $\Gamma_D \sim 3.5 \times 10^{-1}$ cm^2/sec. At $q \sim 10^5$ cm^{-1} (exciting-light frequency $\nu = 1/\lambda \sim 16 \times 10^3$ cm^{-1}, scattering angle $\theta \sim 90°$) the contributions to the MB-component widths due to viscosity, temperature conductivity and diffusion are $\sim 4 \times 10^{-4}$, 1.5×10^{-4}, and 2×10^{-2} cm^{-1}, respectively.

Rawson et al. [7] obtained the MB spectrum in a number of pure gases at $P \sim 100$ atm. At $\theta = 90°$, $\lambda = 6328$ Å, and an apparatus-function width ~ 0.02 cm^{-1}, these authors were unable to measure the width of the MB components. This means that $\delta\nu_{MB}(\eta,\chi) < 0.002$ cm^{-1}, in agreement with the calculation presented here.

Thus, in the case considered by us $\delta\nu_{MB}$ is determined completely by diffusion. The width of the central component $\delta\nu_c$ is also determined predominantly by diffusion, and amounts to $\delta\nu_c = Dq^2/\pi c \sim 0.0015$ cm^{-1}. The MB components are shifted by an amount $\Delta\nu \sim 0.045$ cm^{-1} and are consequently easily resolved.

The method proposed here may be superior to the usual methods [8] in sensitivity, accuracy, and speed of determination of D.

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[1] L. D. Landau and E. M. Lifshits, Mekhanika sploshnykh sred, Gostekhizdat, 1954 [Fluid Mechanics, Addison-Wesley, 1958].
[2] R. D. Mountain and J. M. Deutch, Journ. Chem. Phys. 50, 1103 (1969).
[3] L. D. Landau and E. M. Lifshitz, Statisticheskaya fizika, Nauka, 1964 [Statistical Physics, Addison-Wesley, 1958].
[4] K. E. Grew and T. L. Ibbs, Thermal Diffusion in Gases, Cambridge, 1952.
[5] I. M. Aref'ev and V. V. Morozov, ZhETF Pis. Red. 9, 448 (1969) [JETP Lett. 9, 269 (1969)].
[6] I. L. Fabelinskii, Molekulyarnoe rasseyanie sveta (Molecular Scattering of Light), Nauka, 1965. [Consultants Bureau, 1968].
[7] E. G. Rawson, E. H. Hara, A. D. May, and H. L. Welsh, J. Opt. Soc. Amer., 56, 1403 (1966).
[8] W. Jost, Diffusion in Solids, Liquids and Gases. N.-Y. (1952).

ON THE LIFETIME OF $^3H_\Lambda$

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Until recently there were considerable discrepancies between theory and experiment with respect to the lifetime of hypertritium. The experimental lifetime of $^3H_\Lambda$ was found by Block [1] to be $\tau(^3H_\Lambda) = (0.95^{+0.19}_{-0.15}) \times 10^{-10}$ sec. At the same time, calculations by Dalitz and Rayet [2] gave for this quantity values (2.28×10^{-10} sec $\leq \tau(^3H_\Lambda) \leq 2.44 \times 10^{-10}$ sec) much closer to the lifetime of the free Λ-hyperon ($\tau(\Lambda) = (2.51 \pm 0.03) \times 10^{-10}$ sec [3]). The latest experiments yielded $\tau(^3H_\Lambda) = (2.32^{+0.45}_{-0.34}) \times 10^{-10}$ sec [4] and $\tau(^3H_\Lambda) = (2.85^{+1.27}_{-1.05}) \times 10^{-10}$ sec [5], which are close to the value of $\tau(\Lambda)$ and to the theoretical estimate of [2].

In deriving the result of [2], certain approximations were made, and their accuracy is difficult to estimate. This pertains, first, to the taking of the δ-function outside the summation over the final states of the system, leading to an allowance to extra states (not corresponding to the conservation laws). Second, the model wave function used in [2] for $^3H_\Lambda$ does not have the correct asymptotic behavior at large distances between the Λ and the deuteron [6], (i.e., $[\exp(-\alpha r_d)]/r_{\Lambda d}$, where $\alpha^2 = 2m_{\Lambda d}\varepsilon_{\Lambda d}$; m_{if} is the reduced mass of i and f and $\varepsilon_{\Lambda d} = (0.20 \pm 0.12$ meV throughout [7]). The purpose of the present paper is to obtain for the lifetime of $^3H_\Lambda$ an estimate independent of these assumptions.

$^3H_\Lambda$ has three different channels of decay with emission of a negative pion [8]: $^3H_\Lambda \to \pi^- {}^3He$, $^3H_\Lambda \to \pi^- pd$, and $^3H_\Lambda \to \pi^- ppn$. Experiments [4] have yielded the quantity $R_3 = W_{II}/(W_{II} + W_{III} + W_{IV}) = (0.38 \pm 0.09)$, where W_n is the probability of n-particle decay. In addition, it is known that W_{IV} is small and amounts to 10% of W_{III} [8]. Since the binding energy $\varepsilon_{\Lambda d}$ is small, it is clear that the main contribution to the amplitude of the 3-particle decay is made by the pole diagram (Fig. 1a). The diagram making the main contribution to two-particle decay is shown in Fig. 1b (see [9] concerning the nonrelativistic diagram technique). In the calculation of the diagrams, the amplitude M_2 was assumed to be constant and its value was