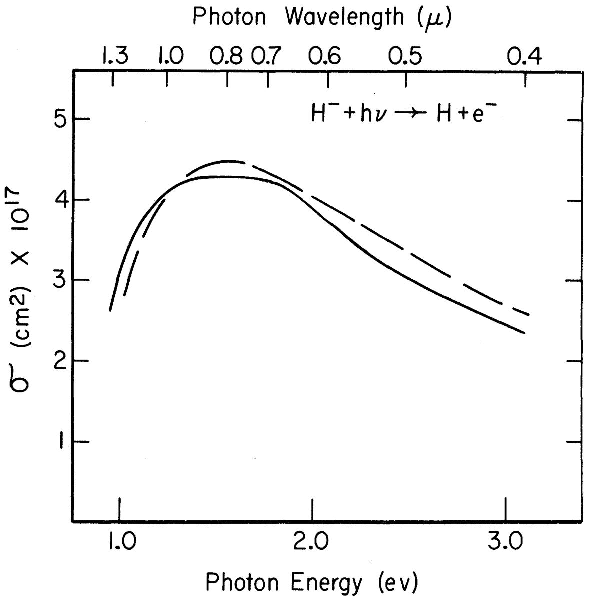

FIG. 2. Experimental cross section for photodetachment (solid curve) on an absolute scale (see text), compared with the theoretical curve of Chandrasekhar and Elbert (dashed curve).

We have used a smooth curve to represent our experimentally determined cross section. This curve, shown in Fig. 2, was put on an absolute scale through use of the Branscomb and Smith absolute measurement[7] of the integrated cross section. While the accuracy in the shape is about 2%, the absolute values are accurate only to 10%.

The present measurement of the shape of the cross section allows a critical comparison of theory with experiment. Included in Fig. 2, for comparison, is a curve drawn through values of the cross section very recently calculated by Chandrasekhar and Elbert[3] using dipole velocity matrix elements, Hart and Herzberg's 20-parameter ground-state wave function,[9] and a Hartree approximation for the free-state wave function. This theoretical curve is in significant disagreement with the energy dependence determined in the present measurement, although it is in fair agreement with the Branscomb and Smith absolute measurement of the cross section.

In addition, Chandrasekhar and Elbert[3] have calculated the cross section at $\lambda = 2985$A (4.15 ev) using the recently available free-state wave functions of Bransden et al.,[10] which include polarization and exchange effects. They obtain a value about 20% lower than the theoretical value based on the Hartree approximation, and point out that there should be smaller differences at lower energies. If so, this fragmentary result is more nearly in agreement with our measured energy dependence, and also appears to be still within the allowable error in our absolute scale. This supports the implication in the work of Bransden et al., that polarization and exchange effects in the free-state wave functions should be considered in the calculation of the absorption coefficient in the visible spectrum. Especially in view of the high degree of refinement already achieved in the development of H^- ground-state wave functions, further progress in obtaining agreement between this experiment and theory seems to depend on the development of free-state wave functions which accurately take account of polarization and exchange.

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PRESSURE-INDUCED INFRARED ABSORPTION OF MIXTURES OF RARE GASES*

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A continuous absorption in the region 300 to 750 cm^{-1} has been observed in compressed helium-neon, helium-argon, and neon-argon gas mixtures. A description and a qualitative interpretation of this new type of pressure-induced absorption will be given here.

The experiments were carried out with an absorption path length of 245 cm and total gas pressures in the range 50 to 180 atm, using a Globar source and a Perkin-Elmer Model 112 spectrometer with a CsBr prism. When the absorption cell was filled with a pure rare gas at the maximum pressure no change in transmission was observed. When a 1:1 mixture of two rare gases was introduced into the cell an absorption was recorded which decreased rapidly in intensity from ~350 cm^{-1}, the low-frequency limit of CsBr transmission, towards higher frequencies. For each pair of gases the intensity profile of the absorption was determined for a series of total gas pressures. The highest absorptions measured were of the order of 50%.

It was established that the absorption at a given frequency is proportional to the product of the partial densities, $\rho_X\rho_Y$, of the two component gases, X and Y, of the mixture. This is illustrated in Fig. 1 (a) where values of $(2.3/\rho_{\text{He}}\rho_{\text{A}}) \times \log_{10}(I_0/I)$ are plotted against the frequency for a He-A mixture; for three different total densities the reduced profile is the same within the experimental error. From the form of the density dependence it can be concluded that the absorption has its origin in binary collisions of the type XY. In such collisions the distortion of the charge distribution of the atoms by intermolecular forces gives rise to a dipole moment which is responsible for the absorption. On the other hand, the distortion of the charge distribution in binary collisions of like atoms has a center of symmetry and no dipole moment is produced; thus, the pure rare gases show no absorption.

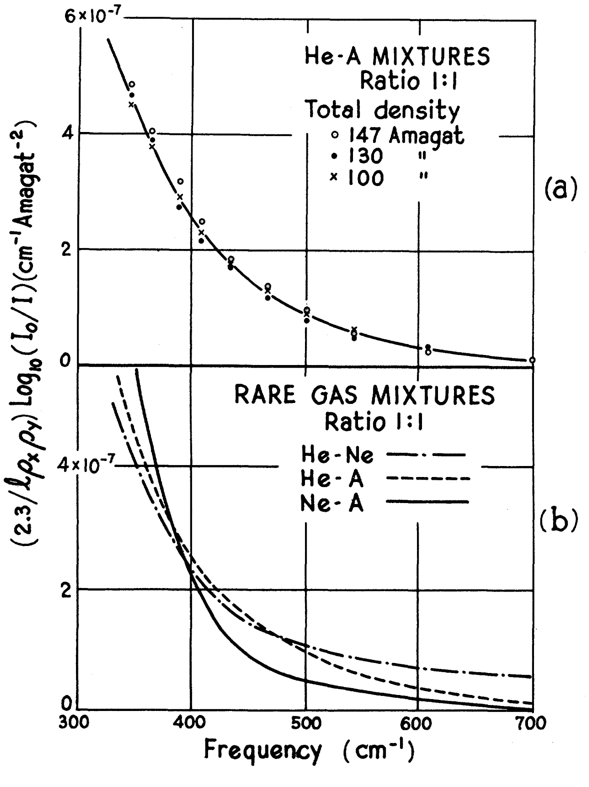

FIG. 1. Infrared absorption of binary mixtures of rare gases: (a) He-A at three different densities, (b) He-Ne, He-A, and Ne-A.

In binary collisions of rare gas atoms the distortion of the charge distribution must be due to overlap forces. Van Kranendonk[1] has shown that in hydrogen-hydrogen and hydrogen-helium collisions the magnitude of the electric dipole induced by the overlap forces falls of exponentially with the intermolecular distance, and one can assume the same type of variation in collisions of unlike rare gas atoms. Since the induced moment thus varies very rapidly with internuclear distance, transitions in the relative kinetic energy can take place under absorption of light. The effect might therefore be called collision-induced translational absorption.

If the translational motion of the molecules is treated classically the absorption arising from a head-on collision is entirely due to the variation of the magnitude of the induced dipole moment with internuclear separation, whereas in a collision with an impact parameter of the order of the atomic diameters the absorption should resemble the rotational absorption of a diatomic molecule. The observed spectrum is a superposition of spectra varying continuously from the rotational type to the pure translational type. The intensity distribution in the rotational-type spectrum should have, like a diatomic molecule, a maximum at a frequency depending on the temperature and the effective rotational constant, B_{eff}, of the combination; beyond the maximum the intensity should decrease gradually towards higher frequencies. There should, however, be no discrete rotational lines since B_{eff} is not sharply defined. In the present experiments only the high-frequency tail of the absorption is observed. To record the rest of the spectrum, in particular the maximum, would require pressure windows which are transparent in the far infrared.

The shape of the absorption depends on the particular pair of rare gas atoms producing it.

In Fig. 1 (b) reduced profiles for He-Ne, He-A, and Ne-A are compared. When the average atomic weight of the collision partners is high, the absorption is higher at 350 cm^{-1} and falls off more rapidly towards higher frequencies. It is evident that not much can be said about the integrated intensity of the absorption until the experiments are extended to the further infrared.

Participation of the relative kinetic energy of the colliding molecules in induced absorption processes has been observed in the pressure-induced vibrational absorption of hydrogen.[2] According to the theory of Van Kranendonk[1] the Q branch of this absorption owes most of its intensity to interaction in the region of the short-range overlap forces, whereas the rotational lines of the vibrational band are due mainly to the longer range quadrupole interaction. Experimentally, the Q branch shows two components, Q_P and Q_R, which have been interpreted as difference and summation tones, respectively, of the vibrational frequency of the hydrogen molecule with a continuum of frequencies associated with the relative kinetic energy. The magnitude of the changes in the translational energy is of the same order as that observed in the collision-induced translational spectra of the rare gases.

Pressure-induced translational continua have also been observed recently in another connection. The pressure-induced rotational spectrum of hydrogen was studied with CsBr optics and compared with intensity calculations based on pure quadrupole interaction.[3] It was found that, particularly in the case of the collisions of light atoms such as H_2-H_2, H_2-He, the observed intensity of the rotational absorption of hydrogen was considerably higher than that calculated, and the profile of the absorption different from that expected. The observations could be explained by assuming that the rotational spectrum was superimposed on a continuum decreasing in intensity towards higher frequencies, and a tentative interpretation of the continuum in terms of translational absorption was given. The present experiments with mixtures of the rare gases confirm that interpretation.

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NEUTRON CROSS-SECTION MEASUREMENTS AT 4.5 Bev*

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In this Letter we report the results of a series of measurements on the total and reaction cross sections for 4.5-Bev neutrons on carbon, copper, and lead.

The experimental arrangement is shown in Fig. 1. The neutron flux is taken at 0° relative to the proton beam incident on an internal target in the Bevatron. The beam-defining collimator is 5 ft long and is located 50 ft from the target; the aperture in the collimator is 2 × 2 in., and hence the emerging neutron beam has an angular spread of less than 0.1 degree. Two lead filters placed in the collimator serve to eliminate photons present in the neutral beam.

The energy distribution of the neutrons is known[1] to be peaked at about 4 Bev and to extend up to the beam energy of 6.2 Bev. The neutron detector described below has a threshold detection efficiency for neutrons starting at 3.5 Bev, hence the mean energy of the detected neutrons is ~4.5 Bev with an energy spread of $^{+1.5}_{-1.0}$ Bev.

Figure 1 shows the neutron detector schematically. It is a counter telescope with three scintillators and a gas Čerenkov counter.[2] First in the beam line is a scintillator connected in anti-

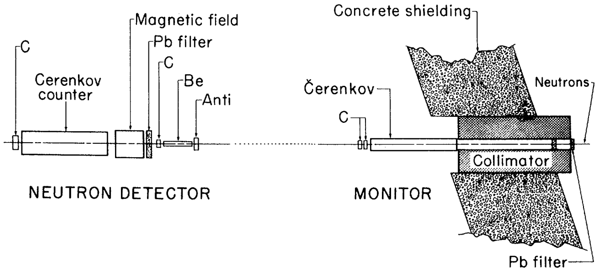

FIG. 1. Schematic of the experimental arrangement, showing the collimator, monitor telescope, and neutron-detector telescope. The absorber is placed in various positions between the monitor and neutron telescopes.