PRESSURE DEPENDENCE OF RADIATIVE PROCESSES IN HELIUM

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The radiative processes in helium are studied. The role of atomic metastable states and of He_2^+ ions is determined.

Our purpose was to investigate the light emission by helium under conditions of low ion density and high pressure. These conditions can be obtained exciting helium gas by means of ionizing particles. The mechanism of the scintillation produced by α particles has been interpreted in terms of electron-ion recombination [1], formation of metastable molecules [2] or as impurities effects [3]. The apparatus used has been described in a previous paper [4]. The He was introduced in the gas chamber through a charcoal trap at liquid nitrogen temperature; other gases could be introduced, as controlled amounts of impurities, down to a minimum value of 2×10^{-4} Torr. An ^{241}Am α source was placed in the chamber. The apparatus, using a quartz window and a photomultiplier 6255 S, was sensitive from 2000 to 5700 Å. To detect the vacuum ultraviolet emission the internal surfaces of the chamber were coated by quaterphenyl as wavelength shifter. The pulse decay time of the u.v. radiation following an α particle emission was measured varying the He pressure. The pressure dependence above 1 atm is similar, but with higher absolute values, to that reported by Takahashi et al. [2]. We cannot explain this disagreement, moreover we find a change in the dependence at lower pressures, as shown in fig. 1. A decay time inversely proportional to the square of the pressure may be due, as suggested by Takahashi, to three-body collisions between a metastable He atom and two ground state atoms, according to the process: $He^m + He + He \rightarrow He_2 + He \rightarrow 3He + h\nu$. A dependence inversely proportional to the pressure, as that we find below 0.8 atm, may be instead caused by two-body collisions. This is an useful indication of the nature of He^m state. An important fraction of the energy expended in atomic excitation is stored in 2^1S state. However 2^3S state cannot be ignored, a priori, on account of excitation by

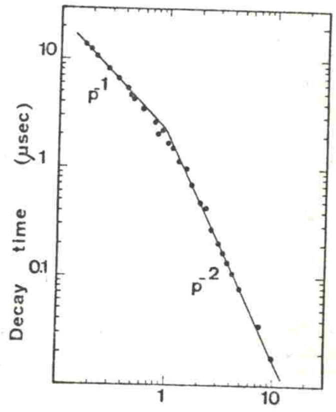

Fig. 1. Pressure dependence of the decay time of the vacuum ultra-violet radiation.

secondary electrons impacts or transfer processes involved in the depletion mechanism of n^1P states [3]. It is known [5] that three-body collisions are the dominant destruction process for 2^3S state above 10 Torr, so that a two-body mechanism prevailing up to 0.8 atm must be due to 2^1S state destruction. We can therefore obtain from the present data the two-body destruction cross section for this state, that results: $(8.5 \pm \pm 3) \times 10^{-20}$ cm^2. Phelps' data [5] may be fitted with a value of $(3 \div 4.5) \times 10^{-20}$; the overall error cannot be easily assigned, but we believe that the two data are in agreement within the accuracy of the two methods. The three-body destruction coefficient for 2^1S state results: $(6 \pm 2) \times 10^{-34}$ cm^2/atom^2 sec (at 300°K). From published data we can have only an upper limit of 6×10^{-33} [5].

A variety of impurities effects are reported in the literature, however are missing systematic data. We have studied the scintillation of He.