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0.615 μm CW Laser Action in a Positive Column He-Hg+ Laser with Mercury Cathode*)

by

J. MIZERACZYK, J. KONIECZKA, Z. ROZKWITALSKI, J. ZIEMANN

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Summary. CW laser action at 0.615 μm in a positive column type He-Hg^+ laser using a mercury cathode is reported. The 0.615 μm sidelight spontaneous emission measurements suggest that the Penning ionization collisions between the He metastable atoms and the Hg metastable atoms can be an important process of excitation of the Hg^+ 0.615 μm laser line in addition to the charge transfer process.

Laser action in excited ionic states of a metal was first observed from the Hg-ion [1]. The laser oscillation occurred there in a pulsed positive-column arc discharge. Since then laser oscillations in ion-metal vapors were widely investigated (see, e.g., the review papers [2, 3]). Although mercury is a promising laser material because

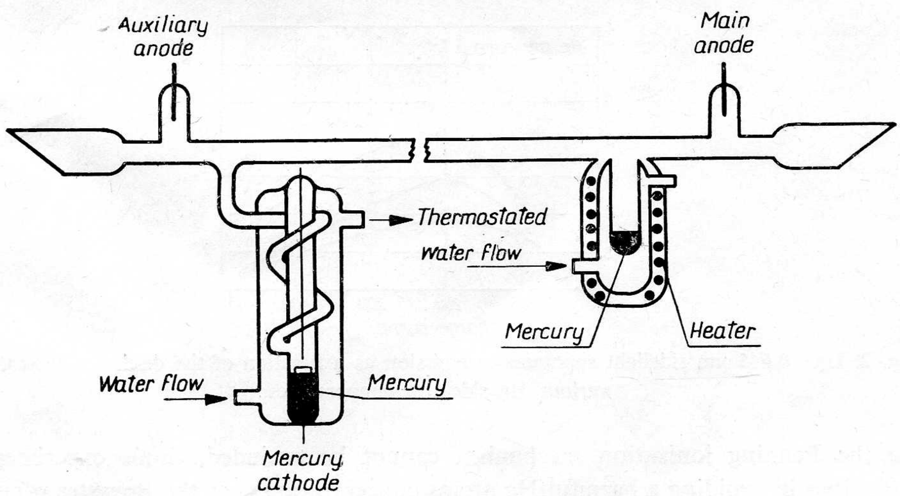

Fig. 1. The diagram of the He-Hg discharge tube with a mercury cathode

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of its favorable vapor pressure at room temperature, amenable chemical properties, relatively simple energy state structure and relatively high laser gain at several lines, only a few papers on laser action in Hg^+ have been reported (see e.g. [2, 3]). They concerned laser action from Hg^+ mainly in pulsed or continuous hollow-cathode discharges. Lately the CW laser actions at 0.615 μm and 0.7945 μm in a positive column type He-Hg^+ discharge were obtained [4, 5]. The results presented in [4] and [5] suggest that the charge transfer collision is a predominant process causing excitation of the upper laser level of He^+ but the possibility of excitation

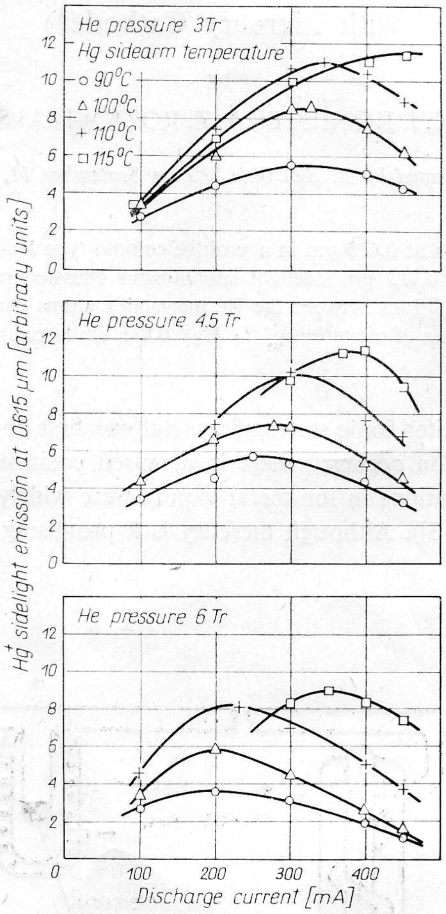

Fig. 2. Hg^+ 0.645 μm sidelight spontaneous emission as a function of the discharge current for various Hg side-arm temperatures

via the Penning ionization mechanism cannot be excluded. Some experimental difficulties in avoiding a harmful Hg atoms concentration near the Brewster window at the cathode region of the tube are mentioned in both the papers.

CW laser oscillation at 0.615 μm in a positive column type He-Hg^+ discharge, taking place in the tube with a mercury cathode (Fig. 1), is reported here. The discharge tube was about a 1 m pyrex capillary with a bore diameter of 3 mm.

The tube was cooled with air by means of fans. Mercury of natural abundance was contained in the 10-cm long capillary side-arm near the anode. The concentration of the Hg atoms in the bore region of the tube was determined by the temperature and transport properties of the thin capillary side-arm. The heating or cooling of the mercury in the side-arm was due to either the flow of thermostated water or the wire oven, as was shown in Fig. 1. To avoid the harmful Hg atoms concentration near the cathode and to prevent contamination of the Brewster window, a mercury cathode was used, and an auxilliary discharge between the auxilliary anode and the mercury cathode has been maintained. The design of the mercury cathode is presented in Fig. 1. The water-cooled mercury cathode was a good natural trap for mercury vapor and further cooling or trapping was not needed. The optical resonator consisted of two mirrors having good parameters for lasing at 0.6328 μm but inadequate for 0.615 μm. This resulted in small laser power emitted outside the resonator. In spite of that it was observed that the laser output follows the behavior of the 0.615 μm sidelight spontaneous emission observed in detail (Fig. 2). The observations were carried out at the discharge currents up to 450 mA only, because of limited thermal endurance of pyrex capillary.

The most significant conclusions which may be drawn from our measurements are as follows: At a given He pressure, the spontaneous emission at 0.615 μm (and the laser output) peaks at higher currents as the Hg pressure is increased. For a fixed Hg pressure the spontaneous emission at 0.615 μm (and the laser output) peaks at lower currents as the He pressure is increased. The last conclusion confirms the results presented in [5].

The measured dependence of the sidelight emission (and laser output) of Hg^+ 0.615 μm line in a He-Hg positive column discharge on discharge current, for a given He pressure, is similar to that for Cd^+ 0.4416 μm line in a positive column type He-Cd^+ laser [6]. Since the primary excitation mechanism of the Cd^+ upper laser level is by Penning collisions, it is believed that this process occurring between the He metastable atoms and the Hg metastable atoms is important for excitation of the upper level of the He^+ 0.615 μm line. This, however, does not exclude the possibility of the charge transfer collisions to be the predominant process of excitation of this line in a positive column discharge, as it was suggested in [4, 5].

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INSTITUTE OF FLUID FLOW MACHINES, POLISH ACADEMY OF SCIENCES, ul. FISZERA 14, 80-952, GDAŃSK-WRZESZCZ
(INSTYTUT MASZYN PRZEPŁYWOWYCH PAN, GDAŃSK-WRZESZCZ)

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Е. Мизерачик, Е. Конечка, З. Розквитальски, Ю. Циманн, **Непрерывная лазерная генерация линии 0,615 мкм в He-Hg^+ лазере с положительным столбом и ртутным катодом**

Содержание. Описывается работа He-Hg^+ лазера на линии 0,615 мкм с положительным столбом и ртутным катодом. Измерения спонтанной эмиссии линии Hg^+ 0,615 мкм показали, что соударения типа Пеннинга между метастабильными атомами He и Hg^+ могут, наряду с процессами передачи заряда, являться существенными процессами возбуждения лазерной линии 0,615 мкм.