# Spectroscopic study of cataphoresis in He-Cd mixtures: Cd source-anode region

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The results of measurements of the axial distributions of the Cd 479.9 nm, $Cd^+$ 441.6 nm, and He 447.2 nm line intensities as a result of cataphoresis in a He-Cd capillary positive column (3 mm diam) between the Cd source, placed at the cathode side, and the anode are presented. The measurements were carried out using optical scanning along the positive column. The measuring procedure also allowed the Cd atom density distributions along the positive column to be determined. It is found that the He-Cd positive column divides into three regions: the seemingly uniform, blue-colored cadmiumlike discharge region, the whitish transition region, and the orange heliumlike discharge region. The Cd atom density decreases linearly from the Cd source towards the anode in the cadmiumlike discharge region of the positive column. In the transition region the Cd atom density decreases quasiexponentially, extending its tail into the heliumlike discharge region. The very tail of the Cd atom density distribution found in the heliumlike region is perhaps not real. Instead it could be due to misinterpretation of scattered background light for fluorescence light. This ambiguity makes it impossible to draw any definite conclusion about the ability of cataphoresis to confine the Cd vapor at the cathode side of the positive column. It is found that particularly the linear but also the quasiexponential decrease of the Cd atom density, occurring in the He-Cd positive column, are in good agreement with Druyvesteyn's theory [Physica **2**, 255 (1935)]. The slope of the Cd atom density distribution curve in its linear part was found to be proportional to the product of the discharge current and He pressure, whereas in its quasiexponential part it first increases and then saturates with increasing discharge current and He pressure. The results obtained can be used for estimating the so-called cataphoretic confinement section length for the positive column and hollow-cathode discharge He-$Cd^+$ lasers, as well as for other ion He–metal-vapor lasers. The features of cataphoresis in the He-Cd positive column found also seem to be characteristic of cataphoresis in other binary gas mixtures.

## I. INTRODUCTION

It is well known that if a dc glow discharge is operated in a binary mixture of gases consisting of a main gas and an admixture gas of a lower ionization potential, the preferentially ionized admixture gas will be transferred to the region near the cathode. This phenomenon, which also can occur in multicomponent gas mixtures, is termed cataphoresis. Cataphoresis, or the selective transport of the preferentially ionized constituent (or constituents in multicomponent mixtures) of a gas mixture towards the cathode, is used for gas purification, isotopic enhancement and, recently, in ion He–metal-vapor lasers. The theoretical and experimental studies in this area have been summarized in the comprehensive surveys by Laška[1] and Chanin.[2]

Cataphoresis has been employed for two purposes in ion He–metal-vapor lasers.[3] First, in the so-called positive column (PC) ion He–metal-vapor lasers cataphoretic transport of the metal-vapor particles from the metal source towards the cathode has been used to establish a uniform distribution of the optically active metal-vapor ions along the PC.[4–6] Second, in both PC and so-called hollow-cathode-discharge (HCD) lasers cataphoretic action between the metal source and the anode has been used for confinement of the metal vapor in the tube section where the discharge excitation of the laser states occurs.[7,8]

The confinement of metal vapor to the excitation section of the discharge tube and prevention of metal-vapor diffusion out of it are current technology problems of both PC (325.0 and 441.6 nm) and HCD (441.6, 533.7, 537.8, 635.5, and 636.0 nm, resulting in the so-called white-light laser beam) He-$Cd^+$ lasers. Two ways of realizing confinement are shown in Fig. 1. In both schemes the Cd diffusion preventing action of cataphoresis occurs in the so-called cataphoretic confinement sections in which the main or auxiliary glow discharges produce positive columns whose axial electric fields make the $Cd^+$ ions drift toward the excitation section, located at the cathode-side region of the glow discharges. This $Cd^+$ ion drift towards the excitation section counteracts the Cd particles' (atoms and ions) diffusion occurring in the opposite direction, away from the excitation section. The confinement efficiency of the Cd particles to the excitation section is given by the difference between the drift flow of the $Cd^+$ ions and the diffusion flow of the Cd particles. Perfect confinement of Cd particles to the excitation section of the discharge tube is desirable in He-$Cd^+$ lasers.

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