Pramāṇa – J. Phys., Vol. 35, No. 1, July 1990, pp. 95–104. © Printed in India.

Three photon resonant ionization in atomic potassium via S, P, D and F series Rydberg states

A SHARMA, G L BHALE and M A N RAZVI
Spectroscopy Division, Bhabha Atomic Research Centre, Bombay 400 085, India

MS received 28 December 1989

Abstract. Single colour three photon resonant ionization (2 + 1) is observed in atomic potassium vapour in a heat pipe oven using an excimer laser pumped dye laser. Using wavelengths between 570 nm and 603 nm various ^{2}S and ^{2}D Rydberg states are populated by two photon excitation. Third photon of the same wavelength ionizes the atoms. Rydberg states up to $n \simeq 50$ are observed. Electric field as low as 1 V/cm causes extensive Stark mixing of the states. This results in progressively higher three photon ionization signals via the perturbed ^{2}P and ^{2}F Rydberg states. The three photon ionization process is studied using both linearly and circularly polarized incident light. The experiment shows qualitatively that the ^{2}P Rydberg states are perturbed primarily by the ^{2}D states in the prescence of an external electric field and to a much smaller extent by ^{2}S states. This is also explained theoretically by calculating the Stark mixing coefficients under the Bates and Daamgard (1949) approximation. Implication for a similar effect in other alkali elements is discussed.

Keywords. Multiphoton resonant ionization; potassium; Rydberg state; Stark mixing.

PACS Nos 32·60; 32·80

1. Introduction

Multiphoton resonant ionization (MPRI) is fast becoming a highly sensitive state-of-the-art technique for trace analysis as well as for many spectroscopic investigations. The main feature of this technique is the ultra high collection efficiency of charged particles and their direct conversion to laboratory signal. The technique depends non-linearly on the light intensity producing the photo ions and electrons following in general the I^n dependance (I being the photon flux and n the number of photons absorbed per atom or molecule). The first direct observation of MPI was reported by Voronov and Delone (1965) in xenon atoms. With the introduction of tunable dye-lasers the MPRI research expanded to the easily ionized alkali-metal and the alkaline earth atoms, metals dimers and to a host of other atomic and molecular species.

A large number of physical phenomena are amenable to investigation by this spectroscopic technique. In the context of this work, only a few experimental investigations have been devoted to multiphoton ionization of potassium atoms. The earliest investigations concerned multiphoton ionization utilizing the 6943 Å ruby laser light (Cervenan and Isenor 1974; Cervenan *et al* 1975; Agostini *et al* 1975). Agostini *et al* (1975) observed three photon resonant ionization of potassium for the first time using a dye laser tuned to 4S–4D and 4S–6S resonance. Delone *et al* (1981) studied three photon resonant ionization of potassium utilizing a dye laser tuned