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Optical-optical double resonance spectroscopy of YO

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Abstract: Laser excitation spectra of yttrium monoxide (YO) have been recorded between the spectral region 294 and 302 nm using optical-optical double resonance (OODR) spectroscopy. The YO molecule was prepared by the reaction of laser ablated yttrium atom with oxygen under supersonic jet cooled conditions. Eight electronic transition bands have been observed via the intermediate $B^2\Sigma^+$ state from the $X^2\Sigma^+$ state. The excited states analyzed so far are in good case (c) coupling scheme and we have identified sub-states with $\Omega' = 0.5$ and $\Omega' = 1.5$, which indicate the existence of $^2\Pi$ state. More interestingly, a $^2\Sigma^-$ state has also been found. Molecular constants for these electronic states were determined.

Introduction: Yttrium monoxide, YO, is one of the most studied transition metal oxide molecules and has been identified to exist in the atmosphere of cool stars [1]. Our interest currently centers on the electronic structure and bonding. Since Group IIIA transition metal atom have the simplest open shell electronic configuration ($(n-1)d^1s^2$), group IIIA transition metal monoxides represent simple prototypical systems. A detail understanding of the electronic structure of YO is desirable in order to rationalize more complicated systems. Three electronic transition systems have been studied in detail and characterized: namely, the green ($B^2\Sigma^+ - X^2\Sigma^+$) system [2, 3], the orange ($A^2\Pi - X^2\Sigma^+$) system [4] and the red ($A'^2\Delta - X^2\Sigma^+$) system [5]. In this work, we report an experimental study of the electronic states in the ultra violet region using optical-optical double resonance (OODR) spectroscopy.

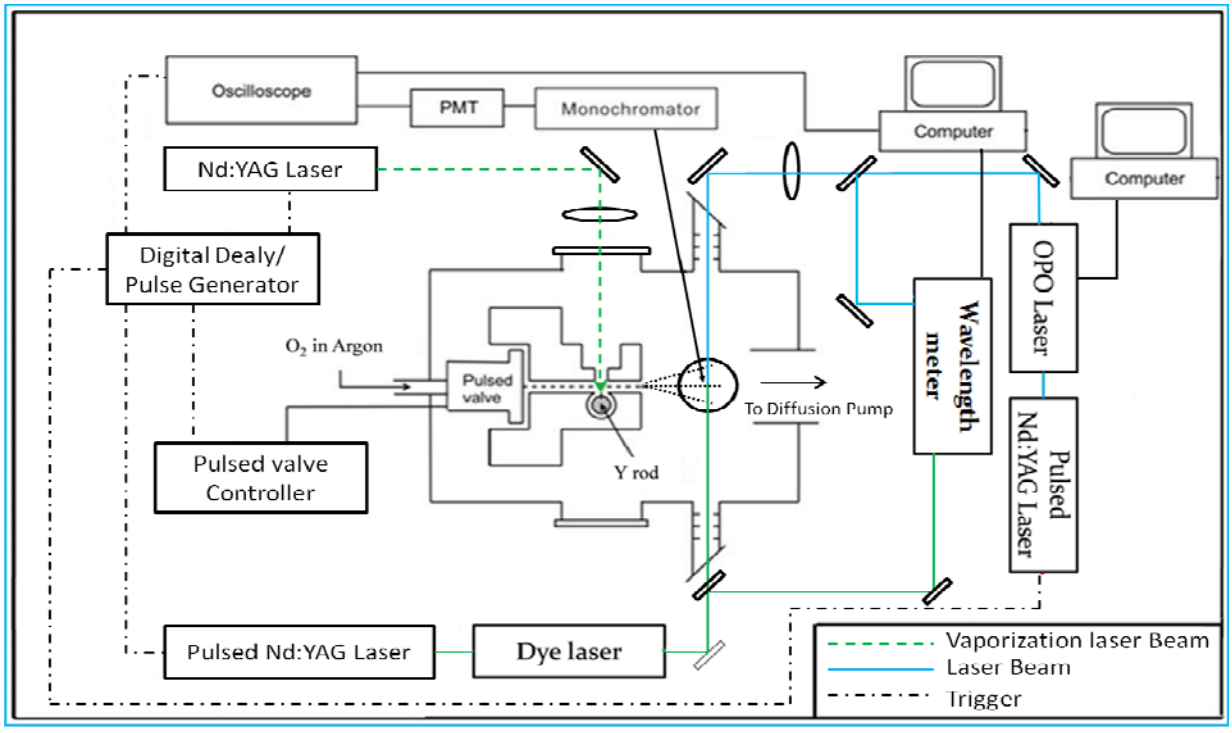

Figure 1 Schematic diagram of the optical-optical double resonance spectroscopy of YO

Experiment: The electronic transition spectrum of YO was obtained using laser ablation/reaction free jet expansion and OODR spectroscopy. Figure 1 presents a schematic view of the experimental setup [6]. YO molecule was produced by reacting laser ablated yttrium atom with 3% oxygen oxide seeded in argon. The jet cooled molecule was then simultaneously excited by photons from two tunable pulsed lasers. The final states in the ultra violet region were reached via the intermediate $B^2\Sigma^+$ state. The fluorescence photon from the final state down to the ground state in the ultra violet region was directed to a monochromator and detected by a photomultiplier tube.

Results: Eight transition bands of the YO molecule have been investigated in the ultra violet region between 294 and 302 nm using optical-optical double resonance spectroscopy via the intermediate $B^2\Sigma^+$ state. Each OODR spectrum typically consists of three lines namely: P, Q and R lines, which indicate each energy level of the upper state is doubly degenerate. One of the recorded spectra is shown in Figure 2. Sub-state including $\Omega = {}^1/_2$ and $\Omega = {}^3/_2$ have been found, band origins and rotational constants were determined using least-squares fit. Molecular constants determined in this work and the identification of a $^2\Sigma^-$ state will also be presented.

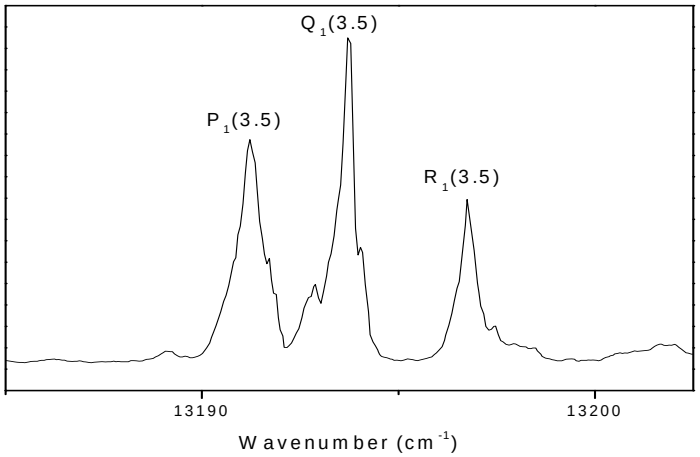

Figure 2 The OORD spectrum of the band with origin T_e = 33934.218(32) cm^{-1} with P(3.5), Q(3.5) and R(3.5) excited from the F_1 component of the $B\ ^2\Sigma^+$ state of YO.

References:

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