다단계 광이온화를 이용한 가돌리늄의 분광학적 연구

Spectroscopic Study on Gadolinium Atom Using Stepwise Photoionization

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Resonance ionization mass spectroscopy (RIMS) is a powerful tool to investigate the states of trace elemen ts such as Gd, Yb, Sm, etc. Recently, a Ti: Sapphire laser pumped by a diode-pumped solid state laser (DPS SL) has become a promising tool for various spectroscopic research fields such as ultrasensitive detection and LIDAR. Here, we have investigated the even-parity states of the gadolinium atom in the ultra-violet (UV) regi on (~400 nm) using single photon excitation [1-4]. The first excited states determined in this work were use d to study newly observed odd-parity states above 37000 cm^{-1} which have not been well known so far. The n, three step photoionization experiments regarding the previously investigated intermediate states will make it possible to explore the even-parity states [4] near the ionization potential (IP) of the gadolinium atom. As a r esult of the investigation of those states, the IP of the Gd atom [4] might be determined precisely.

In this experiment the Nd:YAG laser (Lumonics, HY750) produced a pulsed laser beam with an energy of around 120 mJ at 532 nm. Using a nonlinear crystal (CD*A), 355 nm wavelength photons with an output ene rgy of ~30 mJ were generated by mixing the fundamental frequency of YAG with doubled 532 nm frequenc y. For one laser experiment, the pump laser of 355 nm wavelength pumped a dye laser with various UV dye solutions in the tuning range of 400 - 530 nm wavelength. For two or three laser experiments, another 532 n m laser beam pumped two dye lasers with visible dye solutions in the tuning range of 630-700 nm. All thr ee lasers had a 10 Hz repetition rate and a ~8 ns pulse width. The temperature inside the oven was above 1 500 °C. Ions generated in the interaction region by lasers were accelerated by using two electric field plates. Ion signals were measured by a multi-channel plate (MCP) biased to -1900 V, integrated by a boxcar, and th en stored in a personal computer through an AD converter.

In sigle color experiment there are three different routes for single color photoionization. The ion signals were from three photon processes: through single photon resonant three photon ionization, through two photon resonant three photon ionization, and through three photon ionization. The new positions of high-lying states c an be expected from these ion signals. The differences in the slope of the signals saturation curve for each p eak are obtained due to different processes for the ionization. Single photon resonant states are saturated more easily than the two-photon resonant states. Beside these, four photon process is possible, although three photon is enough to ionize the gadolinium atom with IP of 49601.45 $\pm$ 0.15 cm^{-1} [4].

Using the even parity intermediate states determined from the single color experiment, we can reach the o dd-parity states above 37000 cm^{-1}. Fig. 1 shows the typical two color multiphoton ionization signals through t he intermediate state (J=2, E= 22334.508 cm^{-1}). The optogalvanic (OG) signals were measured simultaneousl y to calibrate laser frequencies. The angular momenta of the states were identified by observing the difference of ion spectra obtained by scanning the same energy range through each different pump paths. The signals w hich appeared at the same energy positions with similar intensity were confirmed as the signals of the states via the common level of first even-parity state. The total energies of several lines matched well with those lis ted in national bureau of standards table and several levels were newly observed. For three color and three st ep photoionization scheme, efficient ionization routes with a large cross-section using the above intermediate st ates will be searched.

References

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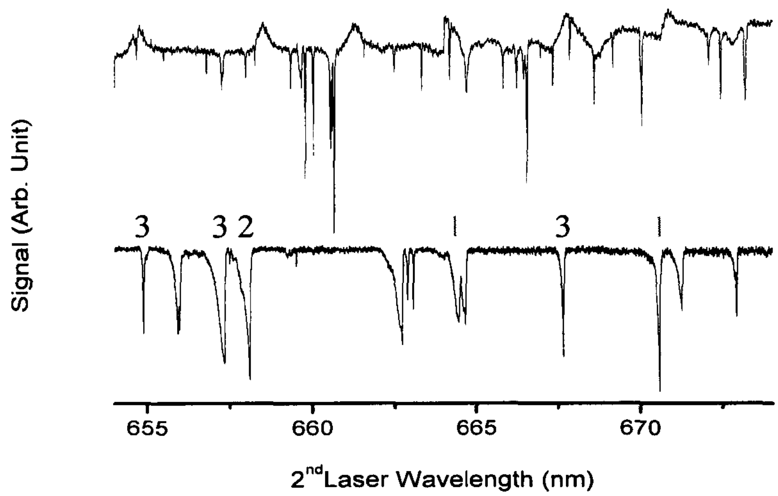

Fig. 1 The typical two color multi-photon ion spectra. Assigned angular momenta J are displayed above the MPI signal. The x-axis is the second laser wavelength through the first intermediate state.