L.8: Isotopically selective OG spectroscopy of Europium using CW ring dye laser

Optogalvanic (OG) spectroscopy is a highly sensitive detection technique to investigate spectral lines of atoms, ions or molecules present in gaseous discharge. The OG effect is the change in impedance of gaseous discharge upon the absorption of resonant light by discharge species. This report presents a study on isotopically selective OG spectroscopy of europium (Eu) in hollow cathode lamp using a single mode tunable CW ring dye laser and a lock-in amplifier, carried out in laser system engineering section (LSES).

Europium has two isotopes (Eu^{151} & Eu^{153}) with natural abundance 47.77% and 52.23% respectively. Both isotopes are used for the production of radioisotopes. Eu152 obtained from Eu^{151} is used as a reference source for gamma spectroscopy while Sm^{153} with high specific activity obtained from Eu^{153} has medical applications. It is used for research in bone cancer and arthritis. Considering these interests, efforts are taken up to measure isotopic shift in Eu for $4f^7 6s^2$, $8S^{7/2} \rightarrow 4f^7 6s6p$, z $^6P_{7/2}$ transition at 576.52 nm. This transition has moderate oscillator strength and lies in the tuning range of Rh6G laser dye. Figure L.8.1 shows the schematic of experimental OG setup that consists of CW ring dye laser, lock-in amplifier, mechanical chopper, hollow cathode lamp wave-meter (WS-7) and a personal computer. A 'Labview' based software developed in LSES is used to acquire & process the OG signals on computer.

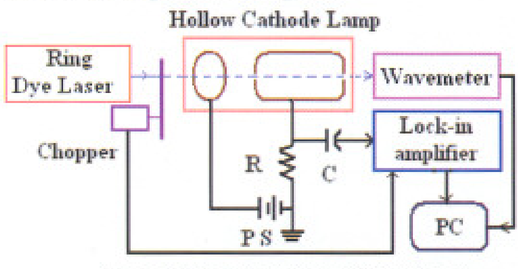

Fig. L.8.1 Experimental OG Setup

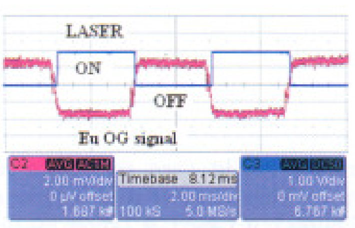

Fig. L.8.2 Europium OG signal at 576.52 nm.

Eu atomic vapours were produced in hollow cathode by sputtering in neon gas discharge. As dye laser beam was made pass through hollow cathode discharge and tuned with Eu transition at 576.52 nm, a small but noticeable change in discharge impedance was observed as OG signal. This Eu OG signal was recorded directly on oscilloscope at 10 mA dc current and 50 mW power (Fig. L.8.2). An Eu/ Ne OG signal spectrum (*by V.K. Saini et al., Proc NLS-20*) as shown in Fig. L.8.3 was recorded earlier using pulsed dye laser and boxcar-averager also. In this spectrum all the peaks except at 576.52 nm correspond to neon OG signals. A small Eu OG peak at 576.52 nm could not be resolved isotopically here. It may be due to broad line-width (> 3GHz) of the pulsed dye laser used.

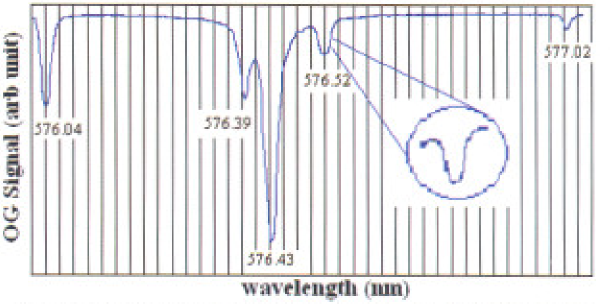

Fig. L.8.3 Eu/Ne OG spectrum using pulsed dye laser

This problem was resolved using single mode (10 MHz) CW ring dye laser that can be tuned mode-hop freely up to 30 GHz. Figure L.8.4 shows a recorded Doppler limited OG profile for Eu^{151} and Eu^{153} isotopes. The relative isotopic shift measurement relies on precision (60 MHz) of the wave-meter used. The relative isotopic-shift ($\Delta\nu$) measured was 3.6 GHz that lies very close to the reported data (3.3 GHz). The observed difference between reported and measured value may be due to Doppler broadening of the lines. It was observed that wings of isotopes do not overlap very much and OG line profile is nearly Gaussian in shape. Measured OG signals peak ratio (Eu^{153} : Eu^{151}) '1.090' closely matches with reported abundance ratio (1.093) which reveals that OG signal follows the abundance of sample. Further, hyperfine studies are under plan using Doppler free OG spectroscopy.

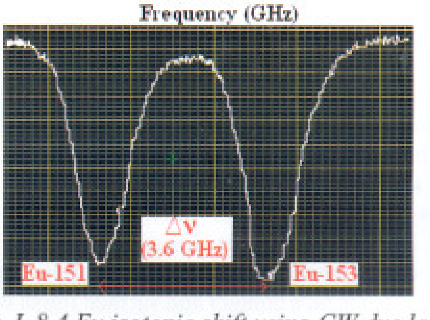

Fig. L.8.4 Eu isotopic shift using CW dye laser

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