

## BUILDING A HIGH RESOLUTION SPECTROMETRY SYSTEM WITH LOCK-IN DETECTION TECHNIQUE

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**Abstract.** high-resolution spectrometry system has been built at the department of Quantum Optics, faculty of Physics, HUS based on a Double Grating Monochromator GDM1000 and a DSP Lock-in Amplifier SR830. Several works concerning with coupling, processing data and spectrum calibration were studied and resolved. With high resolution of the spectrograph GDM – 1000 and high sensitivity of the Lock-in amplifier SR830, this instrument is very helpful for analysis of molecular spectra and research in material science field.

### 1. Introduction

Studies of Fluorescence and Raman scattering Spectroscopy always require a spectrometer of high sensitivity and high resolution. When improving an old spectrograph GDM -1000 of CarlZeiss/Jena we studied to design and construct a spectrometry system coupled with computer using Lock-in detection technique. The major advantage offered by lock-in amplifier is the ability to reduce noise and recover weak signal. Using a computer for control, synchronizing and processing increases automatic capability.

### 2. Experimental results

We used a double grating monochromator GDM-1000 of CarlZeiss/Jena with the first order spectra region of  $7500\text{cm}^{-1} - 16675\text{cm}^{-1}$  ( $6000\text{\AA} - 13300\text{\AA}$ ) and the second order spectra region of  $16675\text{ cm}^{-1} - 28700\text{ cm}^{-1}$  ( $3600\text{ \AA} - 6000\text{ \AA}$ ).

After removing the auto recorder, a stepper motor was used to control gratings (Fig.1). Our measurements showed that one step of motor corresponding to  $0.0832\text{ cm}^{-1}$  of wave number. The circuit controlling stepper motor through parallel port of computer is shown in Fig. 1. A sequence of digital signal is sent to LPT port: 0001; 0011; 0010; 0110; 0100; 1100; 1000; 1001 corresponding to position steps 1→2→3→4→5→6→7→8. Details of "Controlling stepper through Parallel Port" can be seen in reference [1].

We used a SR830 DSP Lock-in Amplifier of Stanford Research Systems to detect spectrum signal from PMT. The SR830 Lock-in Amplifier may be remotely programmed via either the RS232 or GPIB (IEEE-488) interfaces. Any computer supporting one of these interfaces may be used to program the SR830. Both interfaces are received at all times. However, the SR830 will send responses to only one interface. We could specify the output interface with the [Setup] key or use the OUTX command at the beginning of every program to direct the responses to the correct interface.

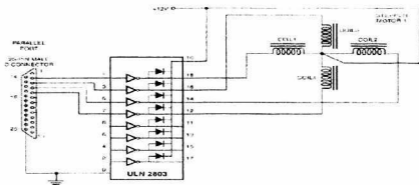


Fig.1. Schematic diagram of stepper controller

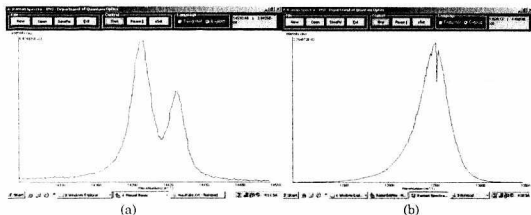
In this research, a GPIB card is used to communicate between computer and SR830. Before attempting to communicate with the SR830 over the GPIB interface, the SR830's device address must be set. The address is set with the [Setup] key and may be set between 1 and 30. Communications with the SR830 use ASCII characters. Commands may be in either UPPER or lower case and may contain any number of embed space characters. A command to the SR830 consists of a four characters command mnemonic, arguments if necessary, and a command terminator. There isn't need to wait between commands. The SR830 has a 256 character input buffer and processes commands in the order received. Similarly, the SR830 has a 256-character output buffer to store outputs until the host computer is ready to receive. Detailed command list can be seen in reference [2]. A computer program has been made coding in Visual Basic to control and to process. A sub for data acquisition and auto sensitive in this program is presented below.

```

*****
Private Sub DataA() ' data acquisition & auto sensitive
Dim status As Integer
Dim l As Integer
Dim r As String
Dim s As Long
Call send (8, "OUTP?3", status) ' test
Call enter(r, 255, l, 8, status) ' maxlen=255
If Val(r) = 0 Then
    Call send (8, "SENS?", status)
    Call enter(r, 255, l, 8, status)
    If Val(r) >= 14 Then
        s = Val(r) - 14
        Call send (8, "SENS" & Str(s), status) ' set new sensitive=oldSens-14
        Call send (8, "OUTP?3", status) ' read R(Vols)
        Call enter(r, 255, l, 8, status) ' enter r
    End If
End If
End Sub
For s = 1 To 27 ' Auto Sensitive
    If (Val(r) >= aSens(s - 1)) And (Val(r) < aSens(s)) Then
        End If
        For s = 1 To 27 ' Auto Sensitive
            If (Val(r) >= aSens(s - 1)) And (Val(r) < aSens(s)) Then
                Call send (8, "SENS" & Str(s - 1), status)
                End If
            Next s
            Call send(8, "OUTP?3", status)
            Call enter(r, 255, l, 8, status)
            ReDim Preserve aR(nmes + 1)
            nmes = UBound(aR)
            aR(nmes) = Val(r)
            txt Watch.Text = n2wn(nmes) & " 1
            " & r & "---->indicator
        End Sub
*****

```

In our laboratory, an Argon Ion Laser (CW, wavelength of 488nm and 514.5nm, power of 2W), a Nitrogen Laser (repetition rate of 10Hz, pulse width of 9ns) and mercury lamps were used as excitation sources for fluorescence or Raman scattering studies. An optical system of optimal conditions for sample illumination was also studied. To examine the function of the achieved spectrometry system we recorded photoluminescence spectrum of natural ruby excited by an UV LED (Fig.2a). This spectrum shows two peaks, which agree well to documentations about the natural ruby. Fig.2b shows the radiation spectrum of the UV led.



**Fig.2.** a - Photoluminescence spectrum of natural ruby sample.  
b - Radiation spectrum of the UV led.

### 3. Conclusions

The spectrometry system coupled with computer using Lock-in detection technique was built at our laboratory. Several works concerning with coupling, processing data and spectrum calibration were studied and resolved. The achieved spectrometry system with high sensitivity and resolution is very helpful instrument for us to study laser spectroscopy such as laser Raman scattering, laser induced fluorescence to research molecular structure and optical properties of semiconductor materials.

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### References

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