UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
I.C.T.P., P.O. BOX 586, 34100 TRIESTE, ITALY, CABLE: CENTRATOM TRIESTE

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INTERNATIONAL CENTRE FOR SCIENCE AND HIGH TECHNOLOGY
c/o INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS 34100 TRIESTE (ITALY) VIA GRIGNANO, 9 (ADRIATICO PALACE) P.O. BOX 586 TELEPHONE 040-224572 TELEFAX 040-224575 TELEX 460449 APH I

H4.SMR/540-14

Second Training College on Physics and Technology of Lasers and Optical Fibres

21 January - 15 February 1991

Optogalvanic Spectroscopy in the Positive Column of a Ne discharge on the $3s_2$ - $2p_4$ Transition

E. Arimondo
Università di Pisa
Dipartimento di Fisica
Pisa, Italy

MAIN BUILDING STRADA COSTIERA, 11 TEL 22401 TELEFAX 224163 TELEX 460392 ADRIATICO GUEST HOUSE VIA GRIGNANO, 9 TEL 224241 TELEFAX 224531 TELEX 460449
MICROPROCESSOR LAB. VIA BEIRUT, 31 TEL 224471 TELEFAX 224163 TELEX 460392 GALILEO GUEST HOUSE VIA BEIRUT, 7 TEL [illegible]

Optogalvanic Spectroscopy in the Positive Column of a Ne discharge on the $3s_2$ - $2p_4$ Transition

Prof. E. Arimondo

The main part of the set-up is composed by a 25 cm long discharge tube, with internal diameter 1mm. The discharge tube has been derived from a commercial He-Ne laser by taking off the end mirrors of the laser, eliminating the reflecting coating and gluing the mirrors back in place. The two electrodes are outside the line of sight not intercepting the propagation of radiation through the tube. The anode is a pin, the cathode is an aluminium cylinder, chosen in order to decrease the outgassing from the cathode material. A stopcock on the side of the discharge tube allows to modify the pressure, and fill the tube with Ne pressure between 0.1 and 2 mbar.

The tube is installed within an electric circuit shown in the Figure, that maintains a discharge between anode and cathode. A R_b =100KΩ ballast resistor from the cathode to ground produces a voltage drop and maintains stable the discharge operation. In order to activate the discharge itself a high-voltage Tesla supply is approached near the discharge tube: the ionization by this high voltage generates electrons that when accelerated by the potential drop across the tube, activate the discharge. The current flowing through the discharge is modified controlling the output from the high-voltage power supply. The operation for optogalvanic detection corresponds to current in the i =3 - 10 m A range.

By running the discharge on for some time at low pressure and low current it is possible to reduce the noise of the discharge itself. This noise is monitored on the oscilloscope, coupled by the capacitor C = 0.001 μF to the ballast resistor. The 1MΩ resistor in series to the oscilloscope input decouples the discharge operation from the detection circuit. Under optimal operating condition all spikes on the discharge current are eliminated and the discharge noise is reduced to approximately $\sqrt{\overline{(\Delta i)^2}}$ = 5 nA.

The Optogalvanic signal is monitored on the oscilloscope when the output from a He - Ne laser, 6mW output power, is injected into the discharge tube. Particular case should be taken in order to align the laser beam and focus properly the laser into the tube in order to have the maximum transmission. In effect the optogalvanic signal is proportional to the amount of laser radiation passing through the tube.

The incoming radiation is mechanically chopped at a frequency in the range 10 - 160 Hz. The detection on the oscilloscope allows to monitor the radiation of the current passing through the discharge as an a.c.. signal.

The optogalvanic signal observed with the present apparatus at He-Ne laser power 6mW, Ne pressure 0.5 mbar, corresponds to :

$$\Delta i_{OG} = 20 \text{ nA}$$

whence

$$\Delta i_{OG} / i = 1 \times 10^{-5}$$

The sign of the OG effect may be derived comparing the relative phase of the OG current modulation and of the photodiode output. The photodiode output produces a negative signal when the incoming light arrives. Comparison of the relative phase for the two signals let's determine a <u>positive</u> OG signal, i.e. an increase in current passing through the Ne discharge when illuminated by a light resonant with the $3s_2$-$2p_4$ transition. For these high-lying levels a positive OG signal may be produced by a difference in the ionization rates in collisions with electrons:

$$Ne^* + e^- \to Ne^+ + 2e^-$$

The $3s_2$ level should have a cross-section for this process larger than the $2p_4$ one.
From a careful check of the signal it turns out that a transient <u>negative</u> OG signal is also present.

The experiment is composed by the following steps:

1. Alignment of the He-Ne through the tube and observation of the OG signal variation with the input laser power.

Because the light absorbed by the Ne tube is so small that cannot be measured, the laser power arriving on the tube may be derived from the transmitted power.
The incident laser power may be attenuated by inserting neutral filters. However misalignment of the laser beam from the discharge tube is an alternative method for reducing the laser light producing OG effect.

2. Tuning the Lock-in for maximum signal.

Before tuning the Lock-in with the OG signal in the input, it is advised to practise on the operation of the instrument when another signal for instance the photodiode output, is applied to the Lock-in INPUT.

For lock-in best operation please notice:

i) The REFERENCE should operate in the SEL-EXT mode. The amplitude of the REFERNCE signal should be reduced to a range where the linearity of the response applies. The PAR Lock-in has the possibility to MONITOR the amplitude of the REFERENCE signal.

ii) Tuning of the FREQUENCY for optimum signal is required. This tuning of the frequency knob is well controlled if the photodiode output is applied to the Lock-in input. When the chopper frequency is modified, the tuning of the Lock-in FREQUENCY should be repeated.

iii) The PHASE of the Lock-in modifies the amplitude of the OUT signal. For optimum operation it is important to control that, after tuning PHASE for maximum OUT reading, a 90^o change in PHASE produces a zero signal on the OUT.

3. Measurememt of the (V,i) characteristic of the discharge and determination of dV/di.

The potential divider across the ballast resistor allows to measure the potential V_C between the cathode and ground. The V_C potential is given by

$$V_C = 3\ V_D$$

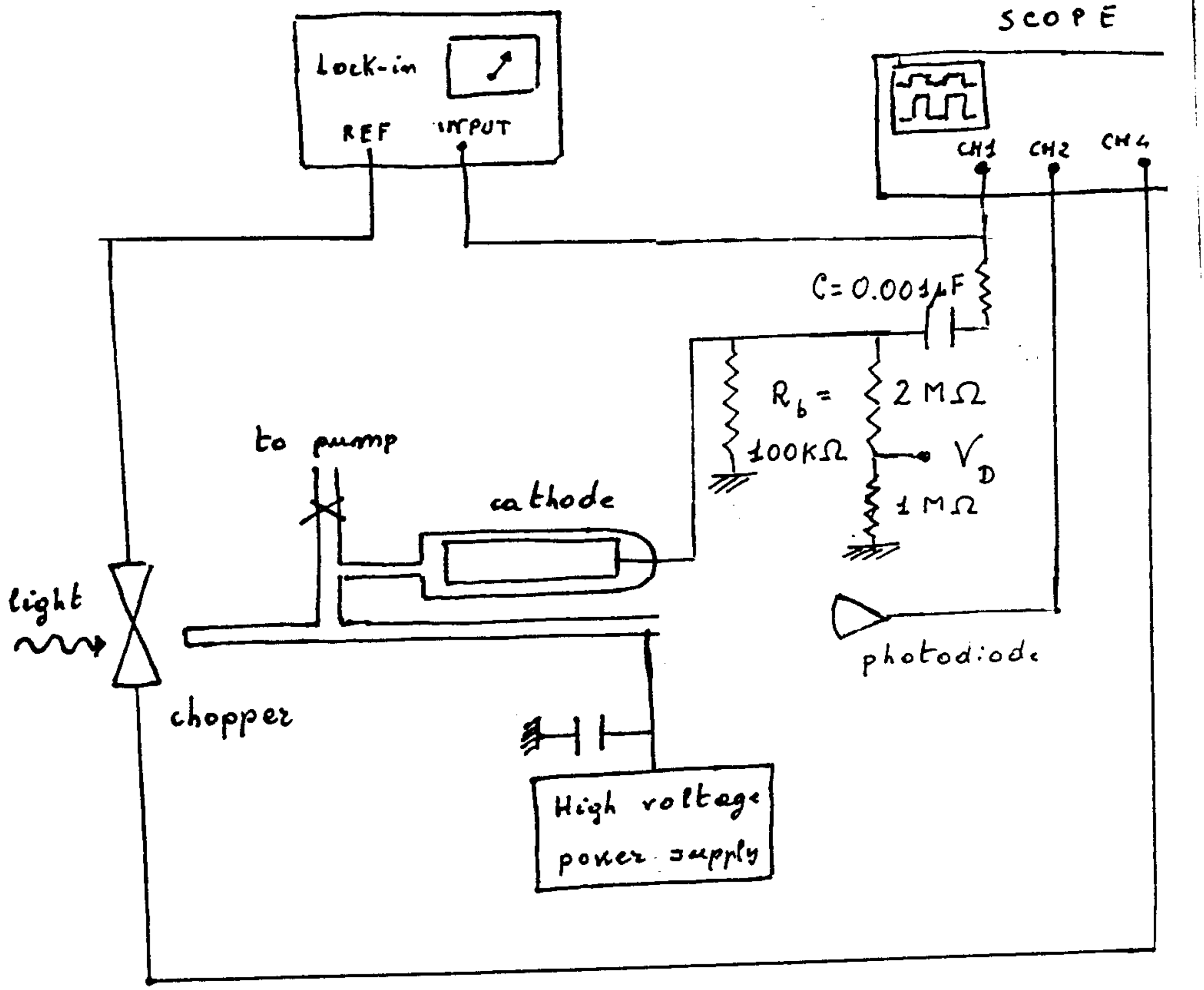
where the V_D potential is measured by a 500 Volts full scale volt-meter. The i current and V potential of the discharge are obtained as

$$i = V_C/R_b$$

$$V = V_{PS} - V_C$$

where V_{PS} is given by the meter on the high-voltage power supply.

Changing the V_{PS} voltage on the power supply, the operating point of the discharge is modified and the (V,i) characteristics may be derived. Depending on the Ne pressure in the discharge tube, a larger or smaller extension of the characteristics may be explored.


Lock-in
REF
INPUT
SCOPE
CH1
CH2
CH4
C=0.001μF
R_b = 100KΩ
2 MΩ
V_D
1 MΩ
to pump
cathode
light
chopper
photodiode
High voltage power supply