BEAMLINES & EQUIPMENTS

Overview of Beam Lines

M. Watanabe

UVSOR, Institute for Molecular Science, Myodaiji, Okazaki 444

There are fifteen beam lines at UVSOR Facility. They are listed in Table I. Four of them (BL2A, BL2B2, BL3B and BL8B2) are mainly used by in-house staffs of IMS, one of them (BL5B) is belonging to the Institute of Plasma Physics, Nagoya University and the others are opened to both inside and outside users of IMS. The front end of each beam line consists of a manual valve, a pneumatic valve, a fast closing valve and a beam shutter. It serves as the interface between the light source and monochromators. There exist four 1m Seya-Namioka, one 3m normal incidence, three plane grating, three grazing incidence and one double crystal monochromators for vacuum ultraviolet and soft x-ray, and one interferometer for far infrared. To these monochromators the equipments for absorption (reflection), fluorescence and photoelectron (photoion) measurements are attached. Standard DC detecting systems and counting systems are provided. Microcomputers are used individually. The date buses are both IEEE-488 and CAMAC. Two beam lines (BL3A1 and BL8A) are devoted to irradiation experiments of solid surfaces with and without gas atmosphere. Gas phase experiments have been carried out at BL2A, BL2B2 and BL3B. Solid state experiments have been made on BL6A1, BL6A2, BL7A, BL7B and BL8B2. At BL2B1 and BL8B1, both gas phase and solid state experiments were made. The lifetime studies of fluorescence were accomplished at BL1B, BL2A, BL3A1 and BL7B under single bunch operation for three weeks.

The numbers of joint studies are given in Appendix.

Table I Beam Lines at UVSOR

Beam Line	Monochromator, Spectrometer	Wavelength Region	Acceptance Angle(mrad) Horiz.	Vert.	Experiment
BL1B	1 m Seya-Namioka	6500-300 A	60	6	Gas & Solid
BL2A	1 m Seya-Namioka	4000-300 A	40	6	Gas
BL2B1	2 m Grasshopper	600-15 A	10	1.7	Gas & Solid
BL2B2	1 m Seya-Namioka	2000-300 A	20	6	Gas
BL3A1	None (Filter, Mirror)		(U) 0.3	0.3	Gas & Solid
BL3A2	2.2 m Constant Deviation Grazing Incidence	1000-100 A	10	4	Gas & Solid
			(U) 0.3	0.3	
BL3B	3 m Normal Incidence	4000-300 A	20	6	Gas
BL5B	Plane Grating	2000- 20 A	10	2.2	Calibration#
BL6A1	Martin-Pupplet	5 mm-50 μ m	80	60	Solid
BL6A2	Plane Grating	6500-80 A	10	6	Solid
BL7A	Double Crystal	15-8 A	2	0.3	Solid
		15-2 A	(W) 1	0.15	
BL7B	1 m Seya-Namioka	6500-300 A	40	8	Solid
BL8A	None (Filter)		25	8	Irradiation, User's Instr.
BL8B1	2.2 m Rowland Circle Grazing Incidence	440-20 A	10	2	Solid
BL8B2	Plane Grating	6500-80 A	10	6	Solid

: Institute of Plasma Physics, Nagoya University. U : with an undulator
W : with a wiggler.

Molecular-beam photoionization apparatus on beamline BL2B2

Katsumi Kimura, Yohji Achiba,[a] and Haruo Shiromaru,[a]
Institute for Molecular Science, Okazaki 444, Japan

The final report on our beamline of molecular-beam photoionization experiments will soon be published in detail elsewhere [1]. In this paper we describe briefly the layout of our VUV beamline including a VUV monochromator and a molecular-beam photoionization apparatus. This beamline has been constructed for studying photoionization of molecular complexes such as van der Waals complexes or molecular clusters in supersonic jets by synchrotron radiation. Several SR studies have already been performed with this apparatus [2-3].

The layout of this beamline (BL2B2) is shown schematically in Fig. 1. The types of three pre-focusing mirrors (M_1, M_2, M_3) and a post-focusing mirror (M_4) are summarized in Table 1. The photon beam from the storage ring is separated by M_1 from the neighboring beamline (BL2B1), then reflected by M_2 to the upper, and further reflected by M_3 down toward the monochromator. The photon beam thus converged makes an image of 0.1mm (vertical) and 13mm (horizontal) on the monochromator entrance slit.

The 1-m Seya-Namioka monochromator used here covers the region 30-150 nm, its parameters being summarized in Table 2. A schematic drawing of the monochromator is shown also in Fig. 1. The monochromator maximum resolution ($\Delta E/E$) is 1×10^{-4}.

The molecular-beam apparatus consists of the beam source, the main chamber, and the beam catcher. The main chamber is separated from the beam source with a skimmer with a hole of 0.7 mm in diameter. A continuous molecular beam is ejected from a nozzle with a pin hole of 50-70 μm. The cooled molecular beam extracted through the skimmer crosses the SR beam. The stagnation pressure up to 10 atm is applicable.

Table 1. Pre-focusing and post-focusing mirrors.

M_1 Cylindrical (3064 cm, y)	M_2 Spherical (2108 cm)
M_3 Spherical (697 cm)	M_4 Toroidal (179 cm, x; 6.5 cm, y)

Table 2. Parameters of the 1-m Seya-Namioka monochromator.

Incident beam	10 mrad (vert.); 6 mrad (horiz.)
Wavelength region	35-150 nm
Grating	2400 lines/mm; Blaze 70 nm
Wavelength accuracy	<0.1 nm
Wavelength reproducibility	<0.005 nm
Resolution	0.01 nm
Entrance slit	20-240 μm (width); 2-16 mm (length)
Exit slit	20-240 μm (width); 2-12 mm (length)

[a] Present address: Department of Chemistry, Faculty of Science, Tokyo Metropolitan University, Setagaya, Tokyo 158.

References (1) K. Kimura, Y. Achiba, and H. Shiromaru, *Rev. Sci. Instrum.*, in press. (2) H. Shiromaru, Y. Achiba, K. Kimura and Y. T. Lee, *J. Phys. Chem.*, **91**, 17 (1987). (3) H. Shiromaru, H. Shinohara, N. Washida, H.-S. Yoo and K. Kimura, *Chem. Phys. Letters*, **141**, 7 (1987). (4) H. Shiromaru, H. Suzuki, H. Sato, S. Nagaoka, and K. Kimura, *J. Phys. Chem.*, in press.

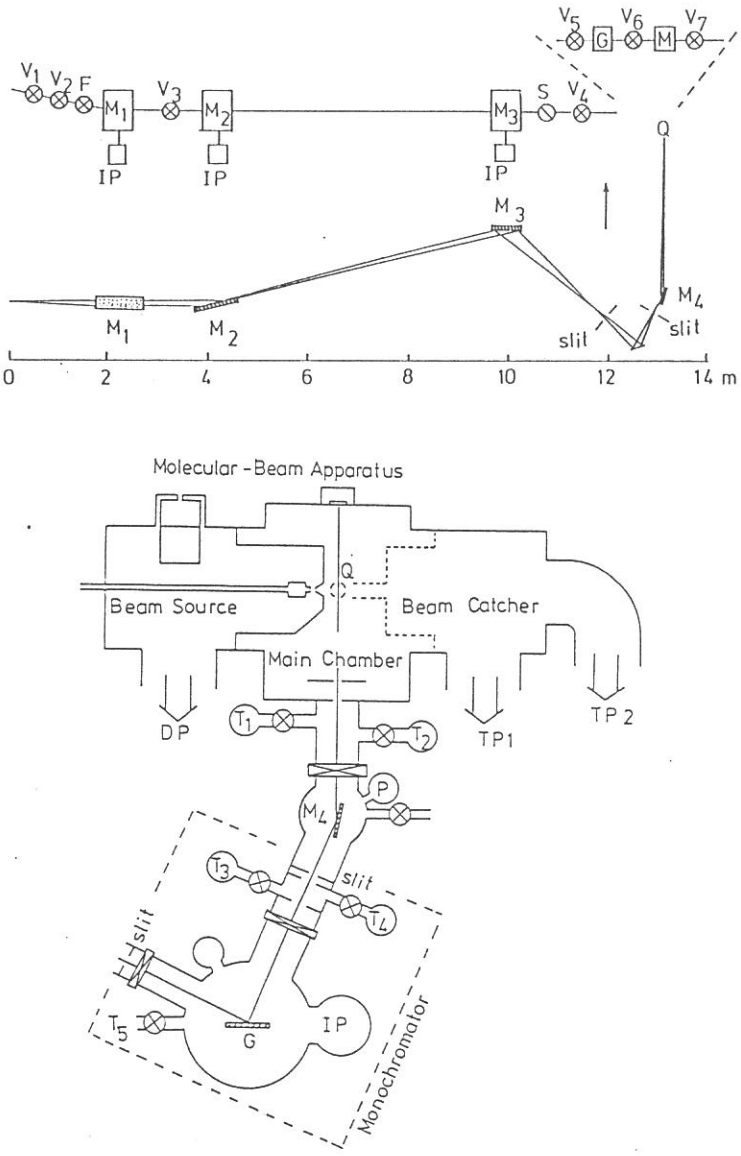


Fig. 1. Schematic layout and drawing of the Beamline BL2B2 at the UVSOR Facility, IMS.

PERFORMANCE OF THE NEW PHOTOIONIZATION APPARATUS AT BL3A2

T. MASUOKA*, T. HORIGOME, and I. KOYANO

*Department of Applied Physics, Osaka City University Sumiyoshi, Osaka 558

Institute for Molecular Science, Myodaiji, Okazaki 444,

The new photoionization apparatus for angle and energy resolved measurements of photoelectrons and photoions[1] is now in operation. New features of it include the main experimental chamber that is rotatable around the horizontal axis of incident photon beam, a 1m ion flight tube with a movable MCP detector in it to allow selection of any desired flight path lengths between 15 and 100 cm, an optical filter system in which any combination of two thin metal-film filters (out of five) can be chosen to remove higher order radiation, and a three-stage differential pumping system which reduces the pressure by a factor of 10^{-5} in a distance of ~70 cm. Figs. 1 and 2 show the mechanism for rotating the whole experimental chamber (which is attached to the rotatable cylinder) and the differential pumping system, respectively, while the section of the ion flight tube is shown in Fig. 3.

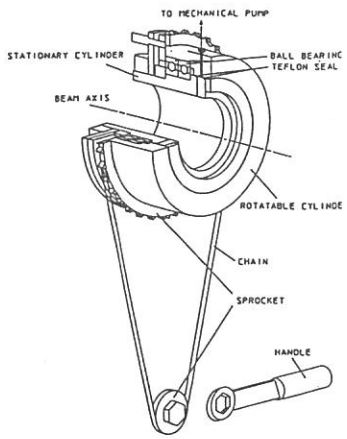


Fig. 1 Mechanism for chamber rotation

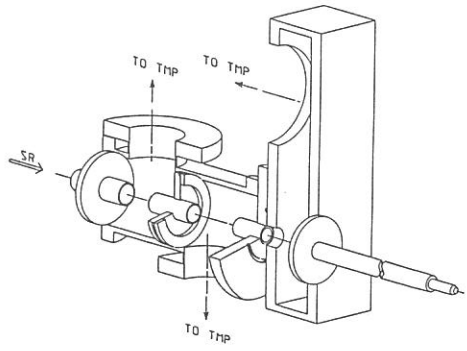


Fig. 2 Differential pumping system

All these new features have been tested and found to work satisfactorily. Fig. 4 shows that the pressure of the grating part of the monochromator is kept in the range of 10^{-9} Torr even when we work at the pressure as high as 1×10^{-3} Torr in the main chamber. Tests also revealed that the vacuum deterioration during rotation of the chamber is negligibly small.

Ionization chamber and electron energy analyzers are set on a table which allows to adjust the chamber-analyzer axis both horizontally and vertically. This set is mounted on an XYZ manipulator in order to allign the set with the photon beam by visual inspection. By now, we have measured the TOF mass spectra and PIPICO spectra of several molecules in their double ionization region using a total electron detector. Coincidence experiments with energy-selected electrons are also in progress.

Reference

1) T. Masuoka, T. Horigome, and I. Koyano, UVSOR Activity Rept. 1987, 23

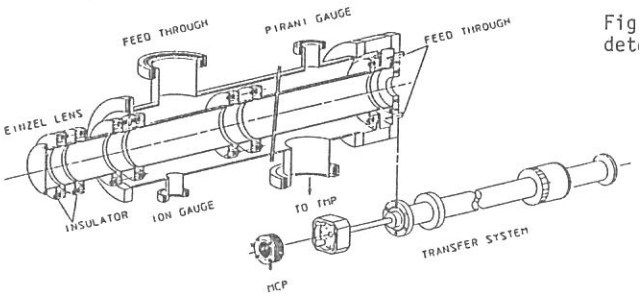


Fig. 3 Ion flight tube, MCP detector, and its manipulator

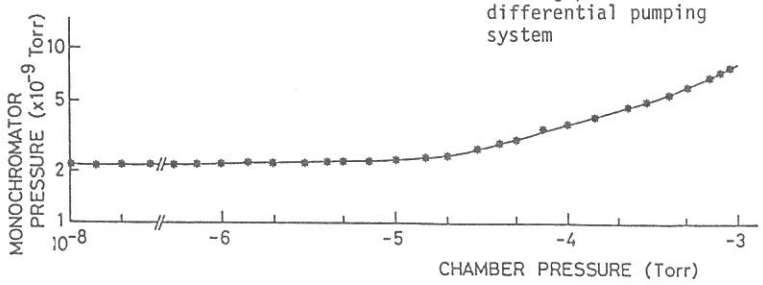


Fig. 4 Pressure relation showing performance of the differential pumping system

PERFORMANCE OF A DODECAPOLE COLLISION CHAMBER FOR THE STUDY OF ION-MOLECULE REACTIONS USING SYNCHROTRON RADIATION

Shinzo Suzuki, Takashi Imamura, Inosuke Koyano,
and Kazuhiko Okuno*

Institute for Molecular Science, Myodaiji, Okazaki 444

*Department of Physics, Faculty of Science, Tokyo Metropolitan University, Setagaya-ku, Tokyo 158

For the study of state selected ion-molecule reactions using synchrotron radiation, the TEPSICO-II apparatus has been installed at the beam line BL3B of UVSOR.[1] This apparatus incorporates a dodecapole ion-beam guide as a collision chamber to collect reactant and product ions completely over a wide range of collision energy and kinetic energy release.

Its performance has been examined utilizing the Ne^+ ions produced by photoionization of Ne at the $^2P_{3/2}$ threshold. Fig. 1 shows the change of the intensity of the primary ion $Ne^+(^2P_{3/2})$ as a function of the potential difference between the ionization region (fixed) and the center of the collision chamber (varied). It has been found that the ion intensity rises sharply as the potential difference reaches zero and then becomes almost constant at higher potential difference. This fact provides a favorable condition for the quantitative study, especially for the study of collision energy dependence, of ion-molecule reactions.

Fig. 2 shows an example of the TOF coincidence spectra for

the primary (Ne^+) and secondary (CO^+, S^+) ions of the reaction Ne^+ + OCS, obtained at the threshold wavelength for $Ne^+(^2P_{1/2})$. The ratio $I(CO^+)/I(S^+)$ obtained from such measurements is 2.1 ± 0.1 and 2.2 ± 0.2 for $Ne^+(^2P_{3/2})$ and $Ne^+(^2P_{1/2})$, respectively, indicating that the spin-orbit state has no noticeable effect on this reaction. The present result differs from that reported previously on the branching ratio in the dissociation of OCS^+ $(C^2\Sigma^+)$.[2] The difference may stem from the difference in the vibrational state distribution in the $OCS^+(C^2\Sigma^+)$ state between ions produced by the two production modes.

REFERENCES

1) I. Koyano, K. Tanaka, T. Kato, and E. Ishiguro, UVSOR Activity Report 1984/85, p.31.

2) F. Carnovale, A. P. Hitchcook, J. P. D. Cook, and C. E. Brion, Chem. Phys., **66**, 249(1982)

Fig. 2 TOF coincidence spectra for the primary and secondary ions of the reaction Ne^+ + OCS, obtained at the threshold wavelength for $Ne^+(^2P_{1/2})$

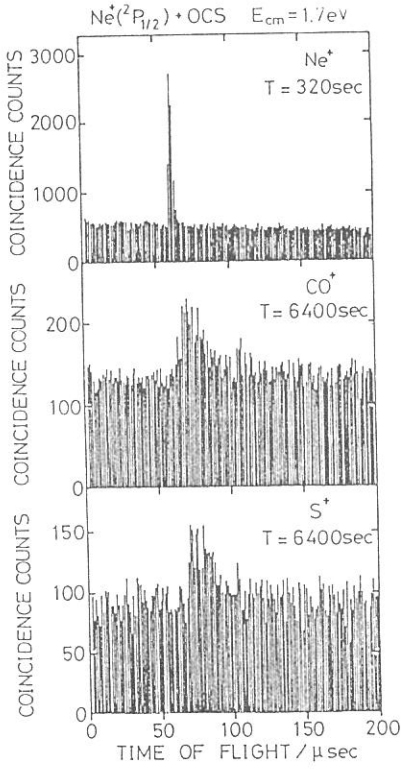
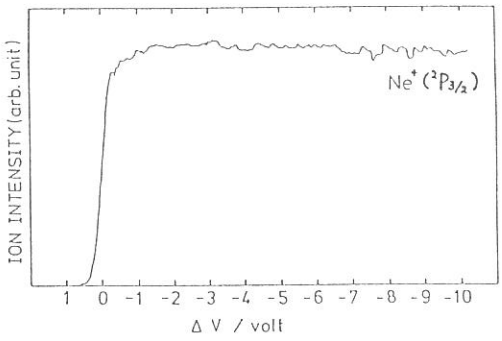


Fig. 1 The change of the intensity of the primary ion $Ne^+(^2P_{3/2})$ as a function of the potential difference (described in the text)



Construction of a beam line for radiometric calibration

Makoto SAKURAI, Sigeru MORITA, Junji FUJITA, Hiroaki YONEZU, Kazutoshi FUKUI*, Kusuo SAKAI*, Makoto WATANABE*, Eiken NAKAMURA*, Eiji ISHIGURO**, and Koujun YAMASHITA***

Institute of Plasma Physics, Nagoya University, Nagoya 464-01
*Institute for Molecular Science, Myodaiji, Okazaki 444
**Faculty of Engineering, Osaka City University, Osaka 558
***Faculty of Science, Osaka University, Toyonaka 560

A new beam line for the radiometric calibration of plasma diagnostic devices has been constructed on BL5B. The beam line consists of a primary monochromator and a calibration chamber. The setup is shown in fig. 1. The primary monochromator (plane-grating monochromator, PGM) is designed to cover a wavelength range of 1.8 to 238 nm with moderate resolution. It has three holographic gratings (G_1 - G_3) and seven focusing mirrors (M_{20} - M_{26}) which are interchangeable in vacuum.

The calibration chamber is equipped with a four-stage differential pumping system which enables to measure the absolute intensity by a rare gas ionization chamber and a photoelectron spectrometer without a gas seal. The suppression of the pressure rise at the monochromator due to a gas flow into the calibration chamber is 10^{-4}. The chamber also contains a co-axial rotational stage for the characterization of optical components, detectors and spectrometers.

Fig.2 shows spectral distribution of the output from PGM for various grating-mirror combinations. It was measured by Al photo diode (fig. 2(a)) and rare gas ionization chamber (fig. 2(b)) at a slit width of 30μm. Photon number at 50 nm amounts to 2×10^{10} photons/s, if secondary ionization effect is negligible. Fig.3 shows expanded absorption spectra near the core excitation regions. Photoelectron yield spectrum from a NaCl photocathode is shown in fig. 3(a). Exciton peaks near $Cl^-L_{2,3}$ edge was observed for G_2-M_{21} combination. The structure in fig. 3(b), which was measured with ionization chamber for G_3-M_{25}, has been interpretted as Beutler autoionization lines of argon. From the FWHM of the progression, the resolving power is estimated at 800.

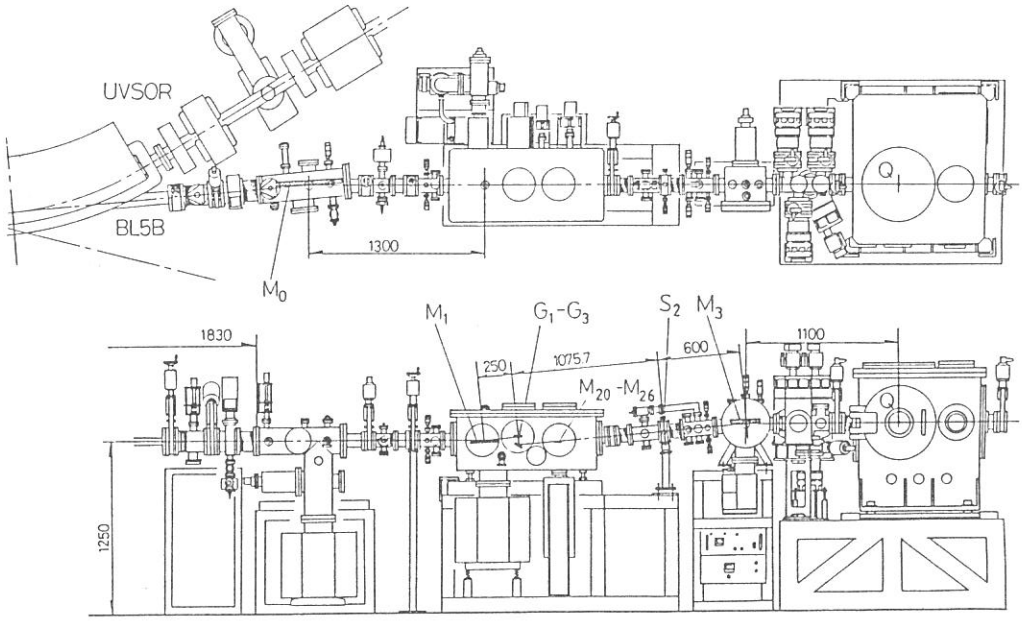


Fig.1. Schematic diagram of BL5B.

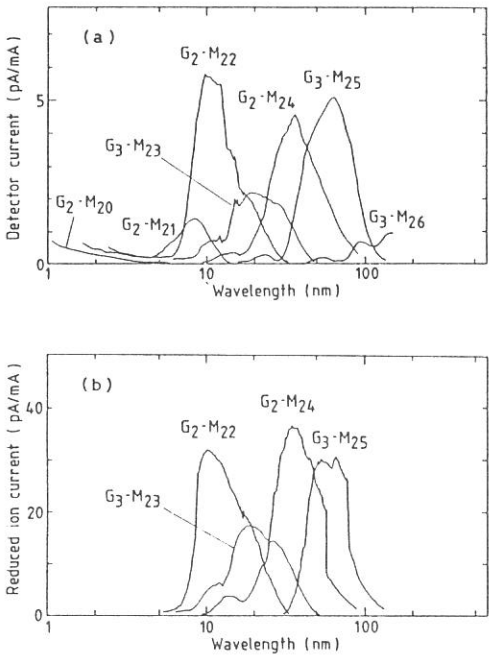


Fig.2. Spectral distribution of PGM measured by (a) Al photodiode and (b) ionization chamber.

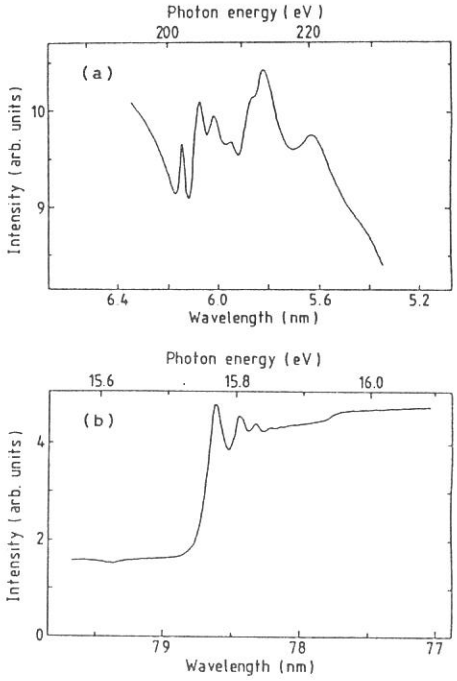


Fig.3. Absorption spectra near (a) Cl L_{23} and (b) Ar M_{23} edges.

DIAMOND ANVIL CELL FOR FAR INFRARED SPECTROSCOPY UNDER HIGH PRESSURE

Takao NANBA and Makoto Watanabe*

Department of Physics, Faculty of Science, Tohoku University, Sendai 980

* Institute for Molecular Science, Myodaiji, Okazaki 444

The study on the lattice vibration under high pressure has been widely made by laser Raman spectroscopy using a diamond anvil cell (DAC). However, Raman technique is not available for materials such as alkali halides which possess an inversion symmetry on the crystal structure because of the Raman inactive character of the optic phonon mode. In such case, direct transmission measurement in the far infrared region under high pressure is required. Up to now, such experiment has been hardly made using black body radiation because of the difficulty of obtaining narrow light beam with sufficient intensity which passes through a DAC. However, our experience at UVSOR proved that the high pressure experiment using a DAC becomes to be easily made because of the high brilliance of the synchrotron radiation in the far infrared region. At the beam line BL6A1, a so-called lever-arm type of DAC was fabricated and installed to the spectroscopic system[1].

Fig. 1 shows a cross sectional view of the stainless-steel liquid helium cryostat containing the diamond anvil cell and its support structure. The DAC mounted on the bottom of the liquid helium tank is lifted by rotating the handle up to the level of the monochromator for the pressure measurement. The pressure induced in the DAC is monitored from the energy shifts of the R1

fluorescence line of a ruby chip which is immersed together with a sample in liquid paraffin which serves as a pressure transmitting material in the DAC. A stainless steel gasket is used. The thickness and diameter of the pinhole of the gasket are 0.2 and 1.0 mm for the usual measurement. Operation of the system at low temperature is on progress.

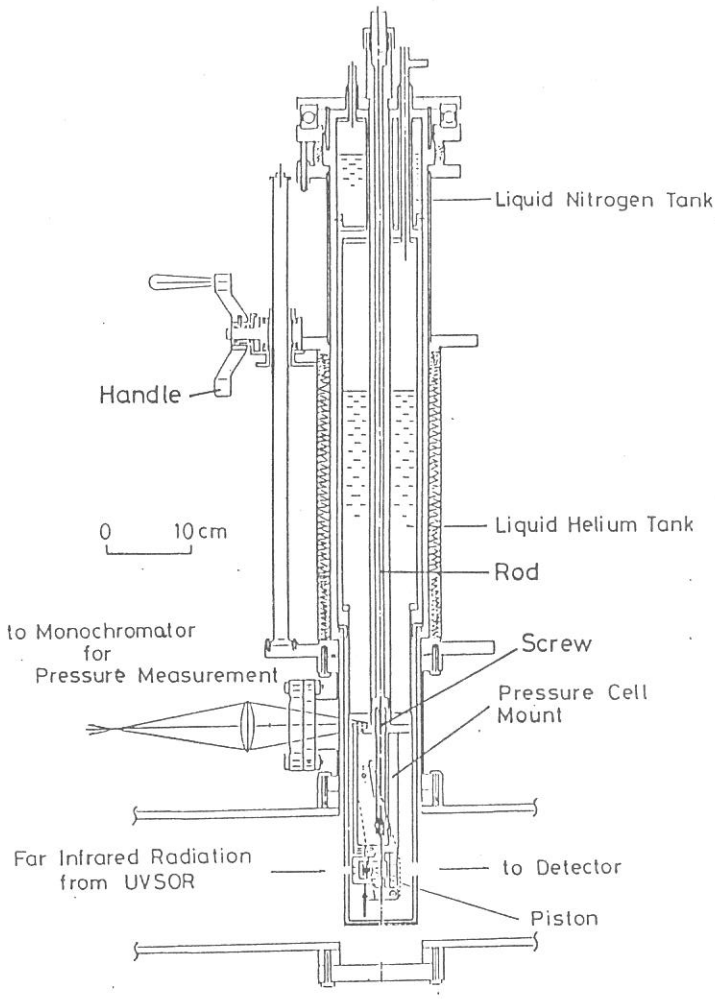


Fig. 1 Cross sectional view of the liquid helium cryostat containing the diamond anvil cell (DAC).

References

1. T. Nanba; Rev. Sci. Instrum. in press (1989).

Delay-time Modulation Spectroscopy Using a CW Mode-locked Nd:YAG Laser Synchronized with the SR Pulses

T. Mitani, H. Okamoto, Y. Takagi, M. Watanabe, and K. Fukui
Institute for Molecular Science, Myodaiji, Okazaki 444
S. Koshihara
Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo 113
C. Ito
Faculty of science, Nagoya University, Chigusa-ku, Nagoya 464

Synchrotron Radiation (SR) from an electron storage-ring can be utilized as a light source of pulses in a wide spectral region from the far-infrared to the soft X-ray. A high repetition rate of the pulse structure of the SR, whose frequency is 90 MHz (the multi-bunch mode) or 5.7 MHz (the single-bunch mode) with a duration time of 460 ps generated at the SR facility of the Institute for Molecular Science is quite suitable for the time-resolved fluorescence and excitation spectroscopies in the subnanosecond time domain.[1] In addition, a high stability of the time structure allows us to synchronize a CW mode-locked Nd:YAG laser (Quantronix 416, 10W) with the frequency of the SR pulses (90 MHz). A new system of the transient spectroscopy has been constructed for the first time by using a delay-time modulation technique. This system opens a unique possibility of expanding a measurable region of transient spectroscopy to infrared and far-infrared regions, where fast optical devices for detection have not been developed as yet.

The experimental instrumentation for the transient absorption measurements is schematically illustrated in Fig. 1. A typical number of monochromatic incident photons of the SR is 10^{2-3} photons/pulse with a spectral resolution of 0.1 %. A maximum averaged power of the laser (the pumping light) is 9.2 W, lasing at the fundamental wavelength (1064 nm), and 1.6 W at the second harmonic, which is contains 5×10^{10} photons/pulse. The two synchronized beams are coaxially focused at the sample in a ca. 0.5 mm diameter spot using a small prism and mirrors. Using the tuning method of the laser pulses as shown in Fig. 1, a delay time of the laser pulses, t_d, measured from the peak position of the SR pulses can be modulated by applying an AC voltage (e.g. 200 Hz) with an amplitude of t. A change of the transmitted SR light induced by the modulated irradiation of the laser beam, which is sensitively dependent on t_d, is detected by a phase-sensitive lock-in amplifier as a modulation signal of the absorption coefficient. The resolution of time in this transient spectroscopy is limited by both of the rise time of the SR pulses and the pulse width of the laser, which was checked by the single-photon counting system[1] to be within 50 ps. These time characteristics of this system is in contrast to those obtained by the transient spectroscopy using a N_2-laser[2], in which the SR was used as a continuous light source, and by the two-photon absorption spectroscopy using the Q-switch Nd:YAG laser pulses with the pulse width of 15 ns, which were synchronized with one

of the SR pulses at the frequency of 30 Hz[3]. In this sense, the present system is considered to have a high sensitivity and to be suitable for the two-step transient absorption measurements under a relatively low density of excitations in a short time period (0.05 - 11 ns). Furthermore, a spurious signal due to a thermal change of the sample by a shot of intensive laser pulse, which occasionally causes a serious problem in low frequency modulation spectroscopy in solids, may be removed from the modulation signals, since it would not follow the high repetition rate of pulses. As an experimental test of the ability of this system, the transient absorption spectra of R6G dye in an aqueous solution has been measured in the visible region. The results was almost in agreement with those obtained by standard laser spectroscopy. It is possible to expand the measurable energy region of this system to the infrared or vacuum ultra-violet region, which is now in progress.

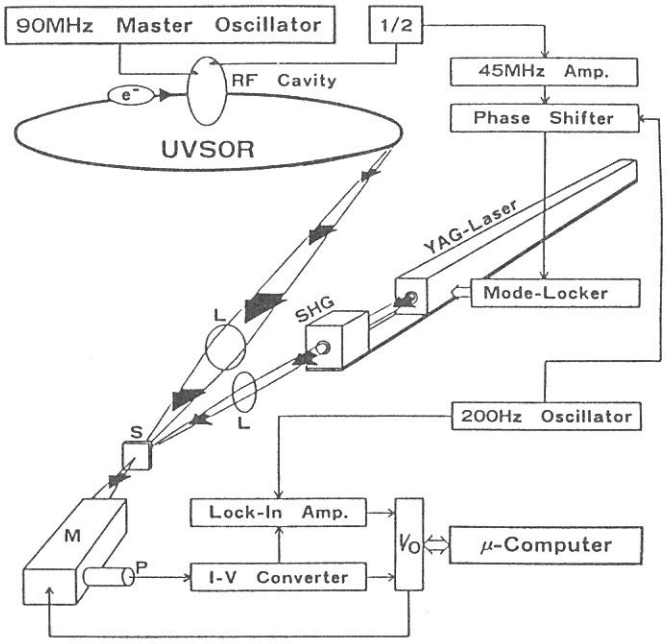


Fig. 1 Schematic diagram of the experimental setup for transient SR spectroscopy

1. T. Mitani, T. Yamanaka, M. Suzui, T. Horigome, K. Hayakawa, and I. Yamazaki, J. Luminescence 39, 313 (1988).
2. V. Saile, Appl. Opt. 19, 4115 (1980).
3. R. Pizzoferrato, M. Casalboni, R. Francini, U.M. Grassano, F. Amtonangeli, M. Piacentini, N. Zema, and F. Bassani, Europhys. Lett. 2, 571(1986).