BEAM LINES

Construction of a 1 m Seya-Namioka Monochromator for BL1B

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At BL1B a 1 m Seya-Namioka monochromator was installed. It is used for both solid state and gas phase experiments. Figure 1 shows the side view of the monochromator. Synchrotron radiation is gathered by a pre-mirror M_1 and deflected vertically upward by 40. The light which passes through the entrance slit S_1 irradiates one of three gratings G, the groove densities of which are 600/mm, 1200/mm and 2400/mm. The monochromatized light passing through the exit slit S_2 is deflected by one of two post-mirrors M_2 so that its axis lies on horizontal plane, and is focused at the sample position Q. The surface of one of the post-mirrors is coated with gold and the surface of the other, aluminum. The beam size at Q is less than 3 mm x 2 mm (WxH). The monochromator was designed to be usable under ultrahigh vacuum. The grating chamber is evacuated by a 500 l/s sputter ion pump and a titanium sublimation pump. At present the pressure is 5 x 10^{-9} Torr.

Figure 2 shows the output signals from the monochromator, which were detected by a photomultiplier coated with sodium salycilate. By the use of three gratings, one can utilize the monochromatic radiation with good quality between 2 and 40 eV. With the entrance and exit slits with 100 m width, the resolution of less than 2 A is achieved by the use of 1200/mm grating. At 2000 A, the photon flux is 10^9/s with the above-mentioned slits at the stored current of 50 mA.

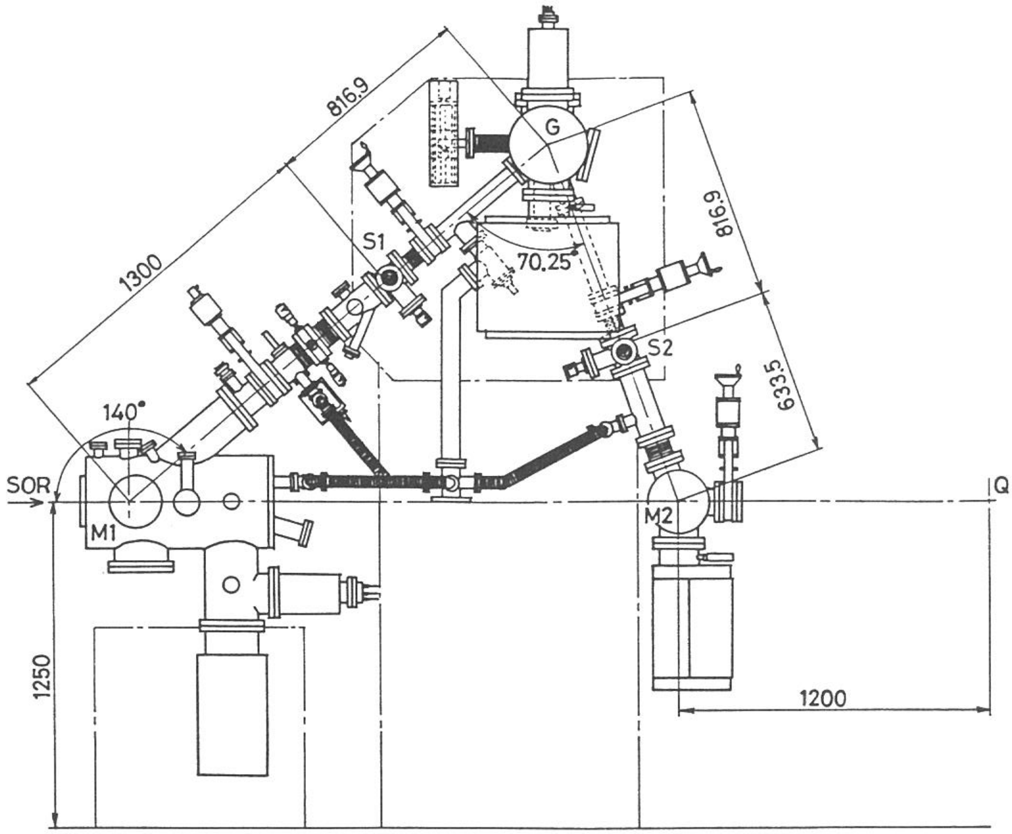

Figure 1. Side view of BL1B equipped with a 1 m Seya-Namioka monochromator.

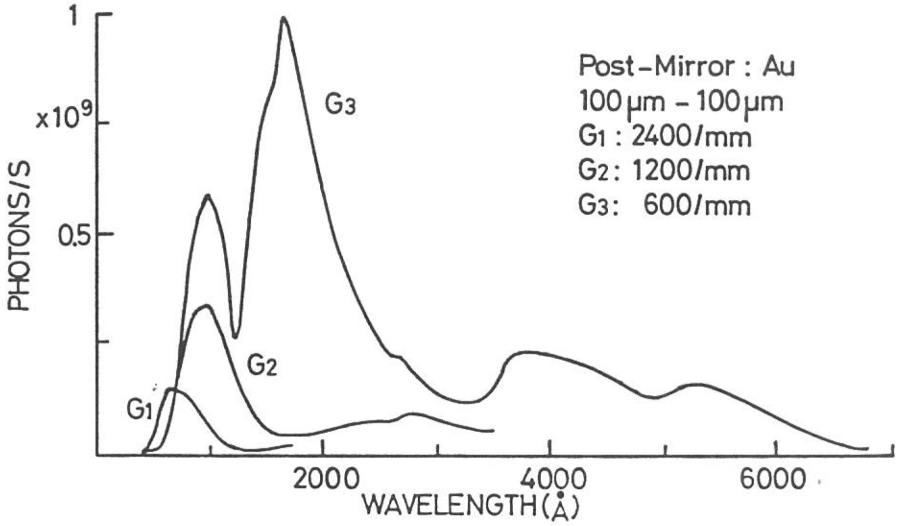

Figure 2. Throughput signals from a 1 m Seya-Namioka monochromator at BL1B at the stored current of 50 mA.

Luminescence Observation System at BL3A1

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The beam line BL3A1 is the undulator beam line without a monochromator. One of the main experiments is observation of luminescence from solid, which can be detected only by the use of intense exciting light. The first order harmonic of undulator radiation is used. The wavelength is chosen by changing the gap of the undulator and the first order harmonic is selected by the use of thin film filters. Typical spectrum of the first order harmonic is given in the report, "2.2 m Constant Deviation Type Grazing Incidence Monochromator at BL3A2" in this issue. Figure 1 shows the plan view of the luminescence observation system at BL3A1. The undulator radiation is focused by a pre-mirror on a sample through a pin-hole of 1 mm diameter. The photon flux after the pin-hole was measured by an aluminum diode, which consists of an aluminum photo cathode and a stainless steel collector. The flux was 10^{14} photons/s, when the wavelength of the first order harmonic was about 300 Å. The monochromator which analyzes the luminescence is a 0.5 m normal incidence VUV-visible monochromator without an entrance slit. The source point of the luminescence acts as the entrance slit. The groove density of the grating is 1200/mm and its ruled area is 100 mm x 100 mm. The experiments by the use of this system are reported in this issue.

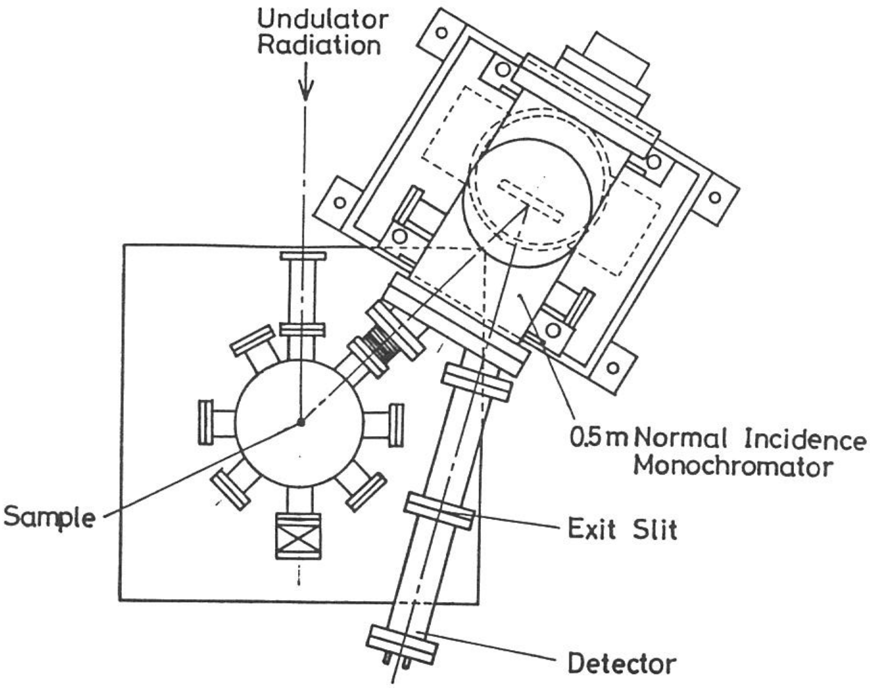

Figure 1. Plan view of luminescence observation system at BL3A1.

2.2 m Constant-Deviation Grazing Incidence Monochromator at BL3A2

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A 2.2 m constant-deviation grazing incidence monochromator can utilize the undulator radiation and the synchrotron radiation from B_3 bending section. It covers the wavelength region of 1000-100 Å using three gratings, the groove densities of which are 600/mm, 1200/mm and 2400/mm and their radii of which are 2217.6 mm. The beam line optics is shown in Figure 1. The positions of the entrance and the exit slits, and the directions of incident and monochromatized lights are fixed. The wavelength is scanned by the rotation of the grating with the translation of the combination of the grating and the plane mirror along the incident light direction. The relative position of the grating and the mirror is unchanged. Figure 2 shows the side view of the monochromator. The distance between the M_3 pre-mirror and the M_5 post-mirror is about 2.9 m. The height of the output beam is about 1.9 m. The grating chamber accommodating the plane mirror moves on a bed inclined by 14°. The entrance and exit slits are connected to the grating chamber with the bellows. Figure 3 shows the spectrum of the first harmonic of the undulator radiation around 250 Å obtained with the 100μ m slits. The higher harmonics were cut with an aluminum filter. The photon numbers behind the exit slit was 10^{12}/s.

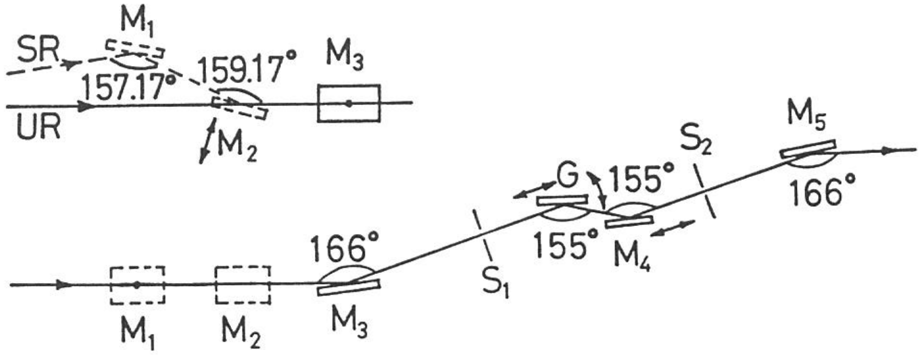

Figure 1. Beam line optics of BL3A2 equipped with a 2.2 m constant-deviation grazing incidence monochromator.

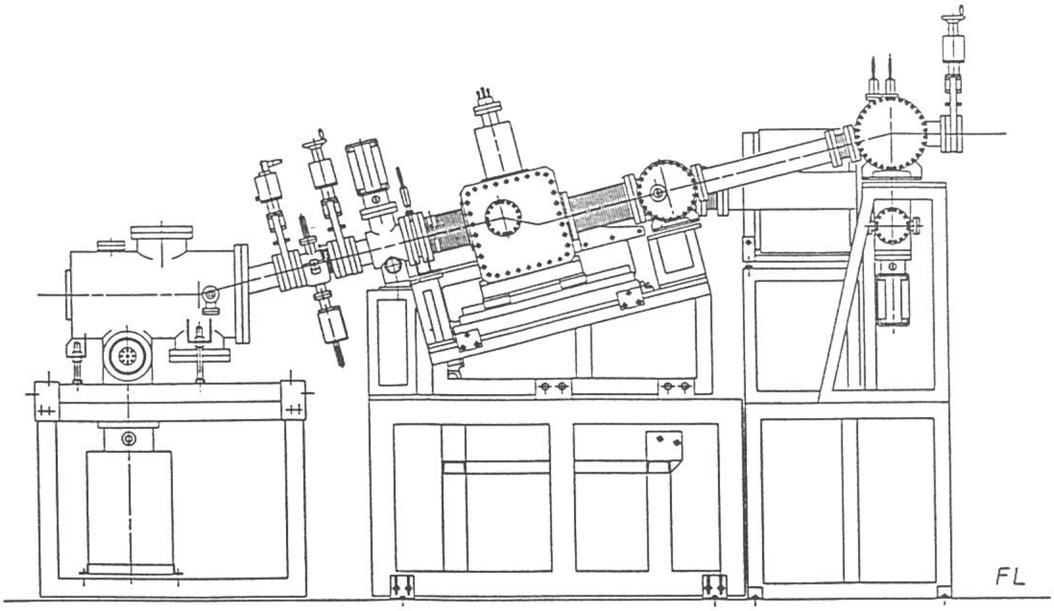

Figure 2. Side view of the 2.2 m constant-deviation grazing incidence monochromator.

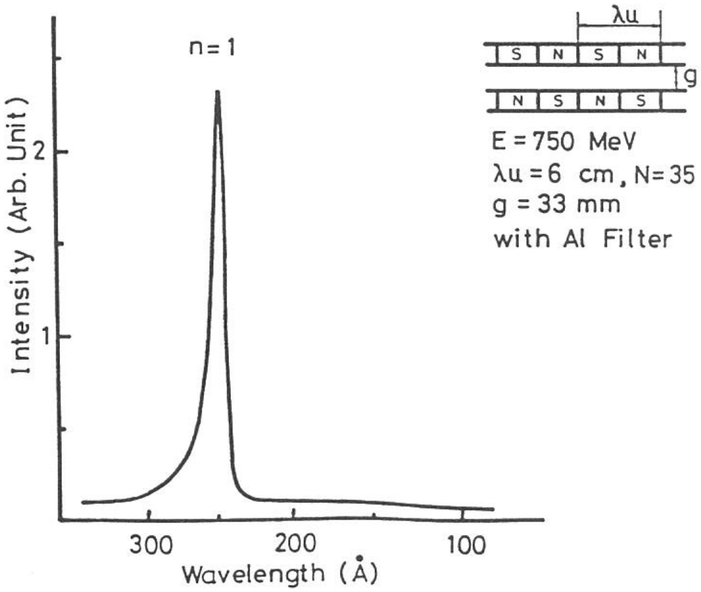

Figure 3. Spectrum of the first harmonic emitted from the undulator at S_3 straight section measured with the 2.2 m constant-deviation grazing incidence monochromator. The higher harmonics were cut by an aluminum filter.

2.2 m Rowland Circle Grazing Incidence Monochromator at BL8B1

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The beam line BL8B1 has been equipped with a Rowland circle grazing incidence monochromator. The radius of the grating is 2217.6 mm. Figure 1 shows the beam line optics. Synchrotron radiation is focused on to the entrance slit S_1 by the pre-mirrors M_1 and M_2. The entrance slit S_1 and the grating G is fixed. The exit slit S_2 moves along the Rowland circle. The direction of the monochromatized light is made fixed on horizontal plane by the two-post mirrors M_3 and M_4. Figure 2 shows the side view of the monochromator. One of two gratings can be chosen with keeping the vacuum, the groove densities of which are 1200/mm and 2400/mm. The scanning range is 200-20 Å with the 2400/mm grating. Three M_4 mirrors are provided. One of them is chosen, the monochromator chamber being opened. Figure 3 shows the photoelectron yield spectrum of KCl obtained by the monochromator using the grating with 2400/mm grooves. The slit widths were 10 μm. The resolution $\lambda/\Delta\lambda$ of 10^3 was achieved with the grating. The photon numbers behind the exit was 10^8/s.

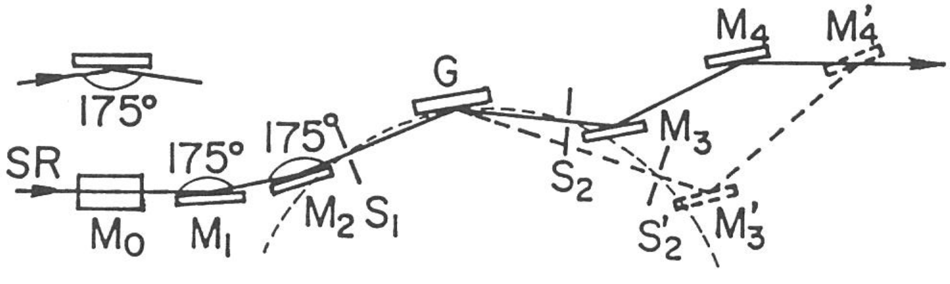

Figure 1. Schematic diagram of the optical system on BL8B1 equipped with a 2.2 m Rowland circle grazing incidence monochromator.

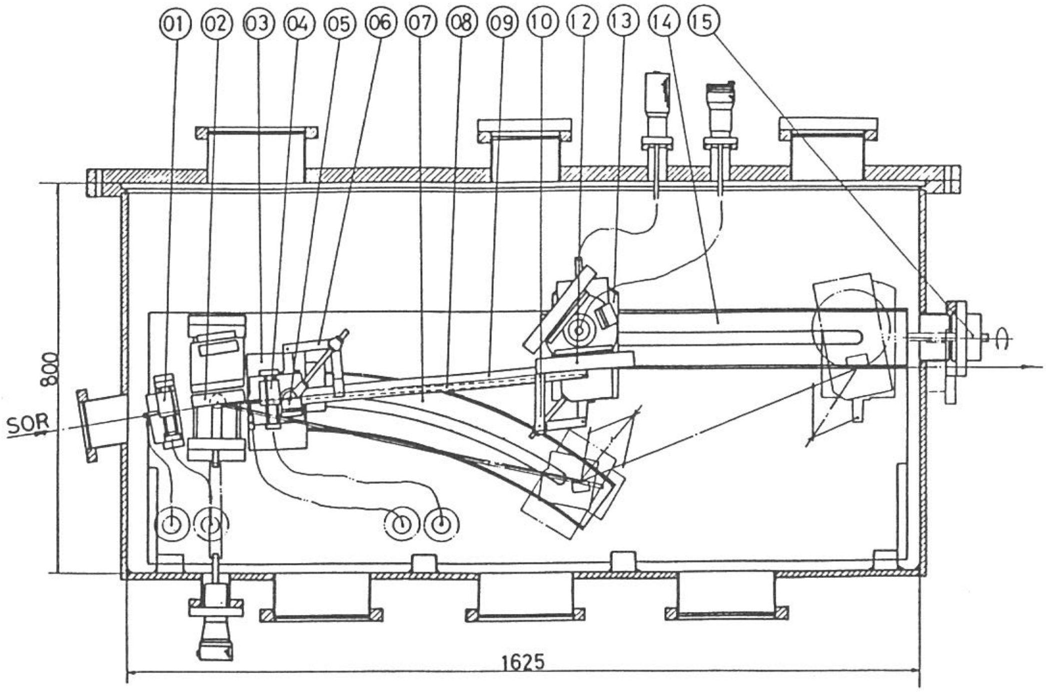

Figure 2. Side view of the 2.2 m Rowland circle grazing incidence monochromator. 01:entrance slit, 02:grating, 04:exit slit, 05:M3 mirror, and 12:M4 mirror.

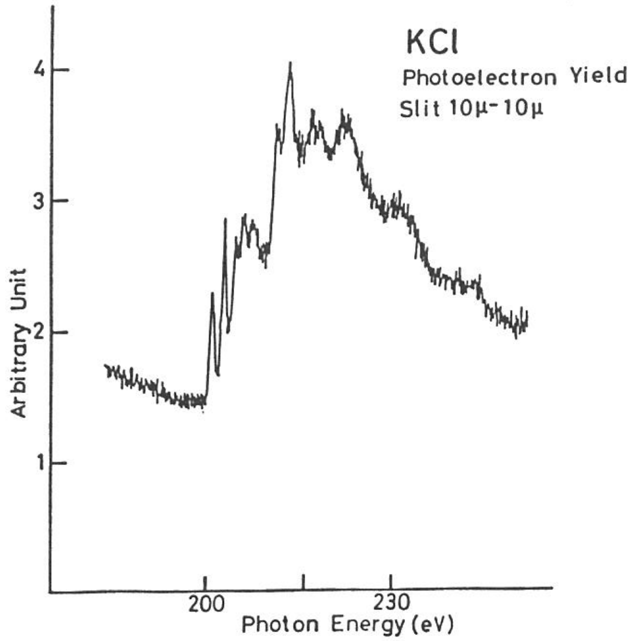

Figure 3. Photoelectron yield spectrum of KCl around the Cl-$L_{II,III}$ edge, obtained by the use of the 2.2 m Rowland circle grazing incidence monochromator.

Cooling of Pre-Mirrors at BL1B and BL7B

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At BL1B and BL7B have been equipped the 1 m Seya-Namioka monochromators. Their beam line optics are similar and that of BL1B is shown in Figure 1. The synchrotron radiation is gathered by the pre-mirror M_1 made of fused quartz and focused on the entrance slit S_1. It had been very annoying that the focused beam got out of position during the experiments under the usual operation condition of 750 MeV and 100-40 mA. It seemed due to the deformation of the mirror and/or mirror holder caused by the heat load of the synchrotron radiation. Then new holders were designed and fabricated, so that the heat can escape easily.

Figure 2 shows the front and side views of the mirror holder at BL7B. The holders are made of copper. The mirror contacts the holder very well through the gallium layer, which becomes liquid even at 35°. The copper block of the holder can be cooled by water. After the use of new holders the beam position has been kept still, even when the holder is cooled only by air. The mirror holders of other beam lines will be improved likewise, as occasion arises.

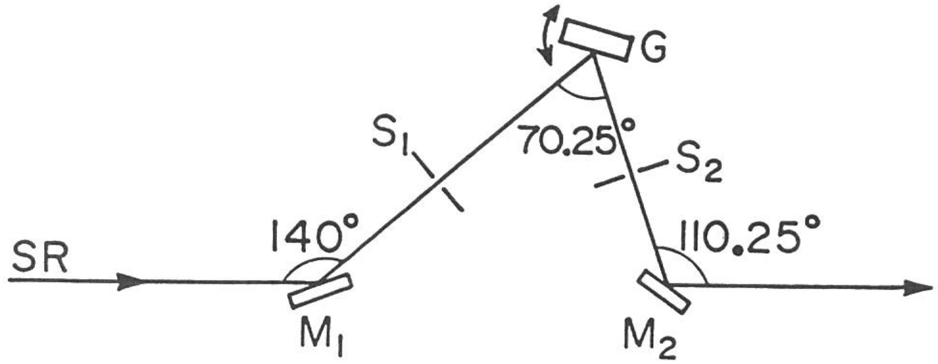

Figure 1. Schematic diagram of the optical system on BL1B equipped with a 1 m Seya-Namioka monochromator.

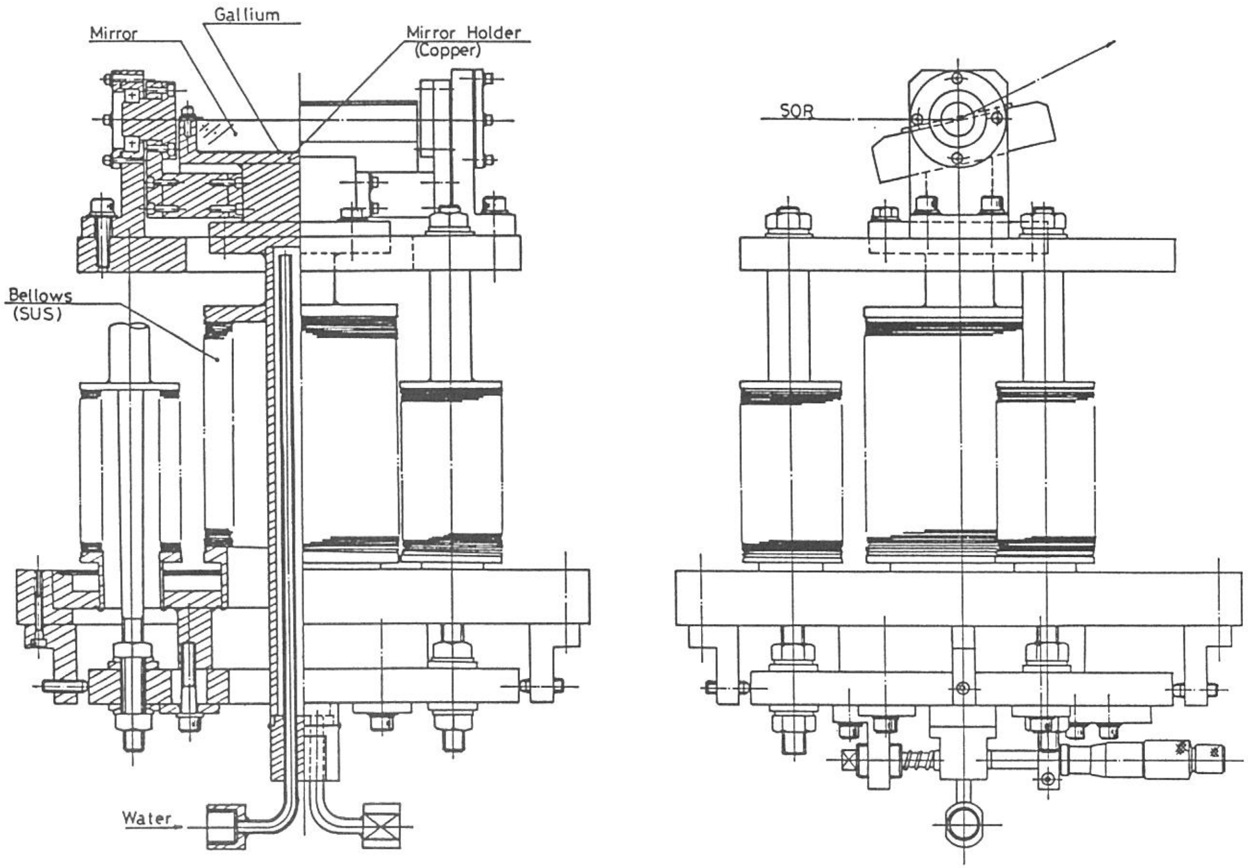

Figure 2. a) front and b) side views of pre-mirror holder at BL7B which can be cooled by water.

CONSTRUCTION OF A SUPERSONIC FREE-JET APPARATUS FOR ABSORPTION AND FLUORESCENCE SPECTROSCOPY OF SUPERCOOLED MOLECULES AND MOLECULAR COMPLEXES

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A supersonic free-jet apparatus for absorption and fluorescence spectroscopy of molecules, molecular complexes, and clusters has been constructed on BL2A. Figure 1 shows a schematic side view of the apparatus. The apparatus consists of 4 parts, a 1-m Seya-Namioka monochromator, a differential pumping section, a vacuum chamber, and a main pumping section. The main vacuum chamber is evacuated through a liquid nitrogen trap by an oil diffusion pump (Varian VHS-10, 5000l/s) backed by a mechanical booster pump (ULVAC YM600-AS, $600m^3/h$). The liquid nitrogen trap can be isolated both from the main chamber and the diffusion pump by an upper and a lower gate valves, and can be evacuated through a chemical trap. This isolatable liquid nitrogen trap enables us to use corrosive or toxic sample. Sample gas is expanded into the chamber through an orifice (0.3mm diam.) attached on a pulsed valve that is modified from a commercial fuel injector. Typical operating conditions of the pulsed valve are 10Hz repetition rate and 40ms duration. Gaseous sample used is either a pure gas or a gas mixture with a carrier gas. A solid or liquid sample is vaporized into a carrier gas at an appropriate temperature.

The monochromatized SOR light is focused on the free-jet 5mm downstream and the transmitted light is monitored by the combination of sodium salicylate coated on the inner surface of the exit window of the main chamber and a photomultiplier tube (PMT). Photon signals of the transmitted light are fed in parallel to two counters each of which is enabled by a gate with a different timing, one corresponding to the free-jet on and the other to the jet off period. In this manner, reliable transmissivity of a sample in a free-jet at a given wavelength can be obtained as an intensity ratio I_{on}/I_{off} regardless of the fluctuations of incident light intensity. Fluorescence is viewed through a quartz lens perpendicular to both the incident light and the free-jet stream line, and focused on a PMT window. Fluorescence signals are counted in the same manner as the transmitted light signals in order to obtain net fluorescence signals by subtracting the back ground signals (scattering, dark counts etc.) that are counted during the jet off. Accumulating for several on-off cycles of the pulsed valve at each wavelength, absorption and fluorescence excitation spectra are obtained simultaneously by scanning the wavelength of SOR light.

At present, the short wavelength limit is 105 nm because a LiF window is used to isolate the vacuum chamber from monochromator. So far direct absorption and emission excitation spectra in the wavelength longer than 105nm are measured successfully for H_2O, D_2O, N_2O, Xe(Xe_2, .., Xe_n), Kr(Kr_2, .., Kr_n), I_2, and I_2/Xe mixture. Replacing the LiF window by a capillary array plate and removing the higher order light by means of noble gas filter filled in the post-mirror chamber, the short wavelength limit can be extended to 30 nm.

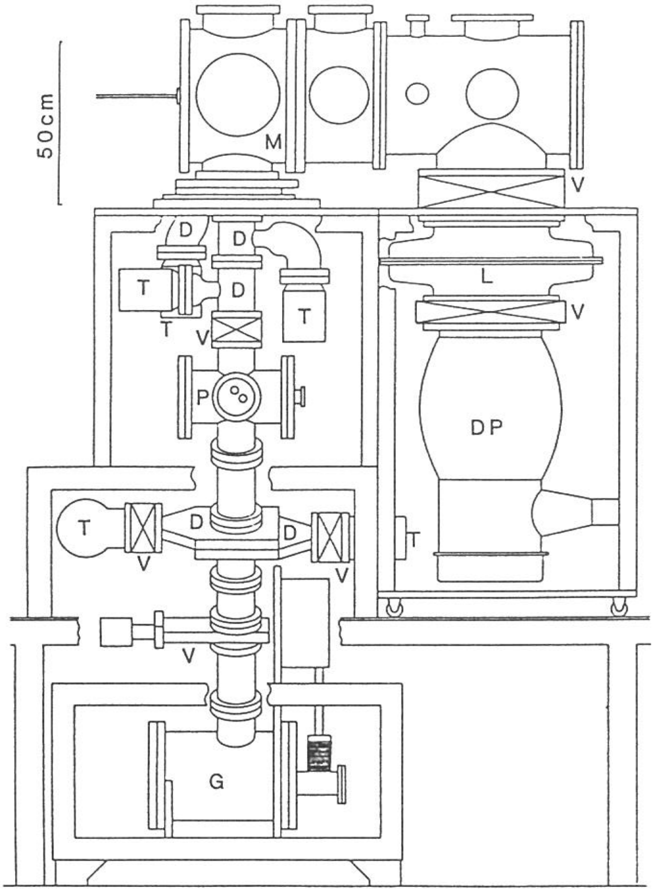

Figure 1. A schematic side view of a supersonic free-jet apparatus. From top to bottom, M: main chamber; V: shutoff valve; D: differential pumping port; T: turbomolecular pump; L: liquid nitrogen trap; P: post-mirror chamber; DP: oil diffusion pump; G: grating chamber.

CONSTRUCTION OF A NEW APPARATUS FOR ANGLE AND ENERGY RESOLVED MEASUREMENTS OF PHOTOELECTRONS AND PHOTOIONS

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A new apparatus for the study of photoionization processes of gaseous molecules has been designed and constructed. Main objectives of the study include measurements of angle resolved photoelectrons as well as time-of-flight measurements of photoions in coincidence with total or threshold electrons. A constant-deviation grazing incidence monochromator on the beam line BL3A2 provides monochromatic radiation ($\Delta\lambda$ = 0.6-2.5 A with 300 μm wide entrance and exit slits) in the region 100-1000 A.

A schematic drawing of the apparatus is shown in Fig. 1. Section A is the pumping section consisting of a main turbo-molecular pump (1000 l/s) for the experimental chamber C and a 3-stage differential pumping system. Novel design is incorporated to attain a pressure reducing factor of 10^{-5} in this short range without interfering with the photon beam. Section B is the mechanism for rotating the experimental chamber around the incident photon beam. With this mechanism, the deviation of the center of ionization region from the beam axis can be maintained within 0.1 mm through 180° rotation of the chamber.

Several types of ion- and electron-detection systems can be set in the experimental chamber. For photoelectrons, the detection of total electrons, as well as the threshold and other energy-selected electrons, are possible. For photoions, both a quadrupole and a time-of-flight mass spectrometer are provided.

The latter is 1 meter long and has three forcussing lenses in order to detect all photoions with kinetic energies up to 20 eV. The flight time of ions can be varied by changing voltages for ion acceleration and/or the position of ion detector in the drift tube. With this variety of detection systems, much more detailed information than before is expected to be obtained on the photoionization processes.

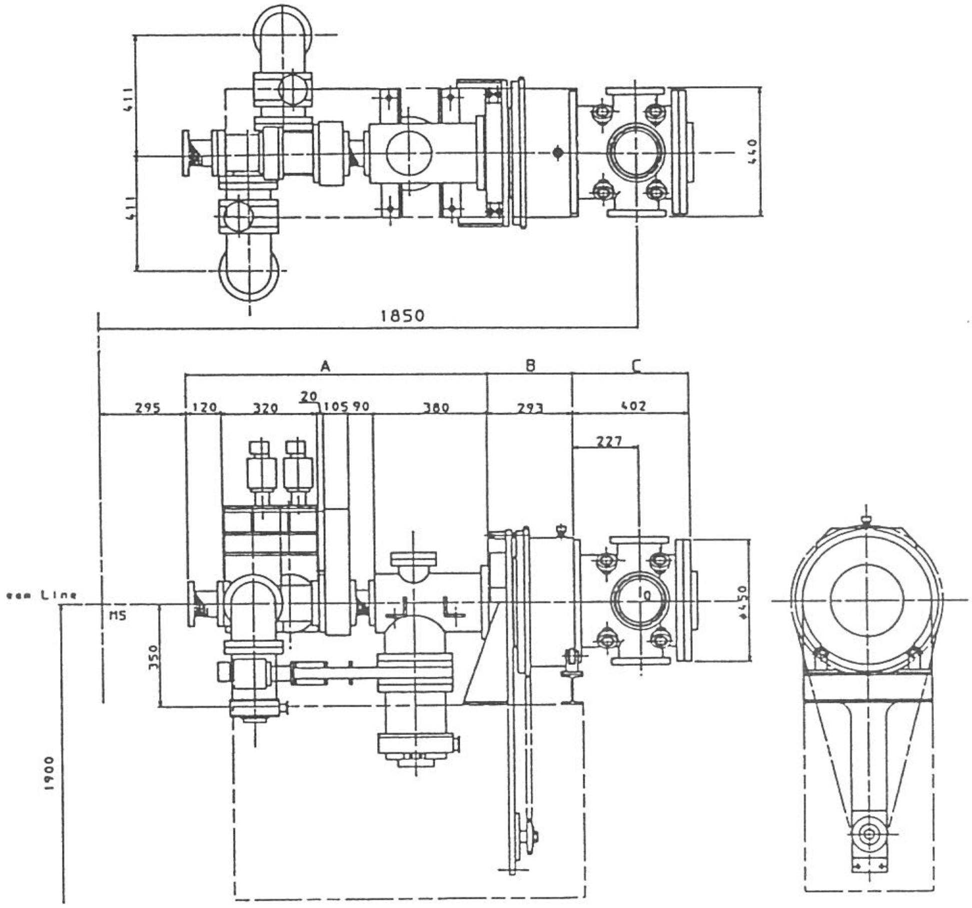

Fig. 1 New Apparatus on BL3A2