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6.65 m Normal Incidence Monochromator for 5 - 40 eV in Synchrotron Applications

Some of the ideal characteristics for a high resolution vacuum ultraviolet normal incidence monochromator have been determined. For operation in the 200 Å to 2000 Å (5 eV to 40 eV) region, specifications include; (1) all components must remain on the Rowland circle, (2) stationary entrance and exit slits, (3) minimal astigmatism, and (4) compact design. McPherson has fabricated several types of long focal length (3 to 6.65 m) spectrometers over its years as a manufacturer. These instruments were either Eagles or McPherson type normal incidence monochromators (McPherson's patented method of changing wavelength and correcting for focus in a design with stationary slits). Recently, interest from the synchrotron community has prompted investigation of designs which might provide higher performance, one of them being the off-plane Eagle. Nominal specifications have been developed for high resolution, high energy monochromator of this type.

I. Introduction

Having decided to adopt the long focal length, off-plane Eagle design for its high resolution performance and minimal astigmatism, preliminary specifications were set. A 1.5° included angle is used, the plane of dispersion is vertical and the slits horizontal. With regard to fabrication, key points are the high tolerance demands put on the rotation and translation of the grating and the quality of the optics used. The role of optical quality is extremely important in a NIM design. Gratings must have the best possible figure for optimum resolution in the vacuum ultra-violet region. Slit designs had to be considered which permitted the entrance and exit centerlines to be as close as practical to obtain the best resolution and line shape. Furthermore, the exit slit requires rotation to obtain best resolution at any one wavelength.

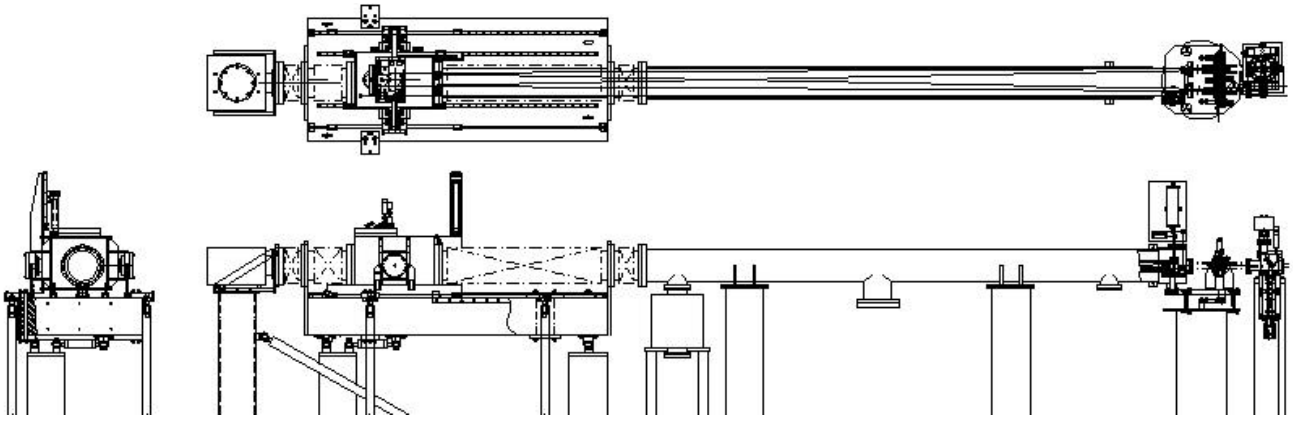
Design criteria for synchrotron applications demands all monochromator components be compatible with ultra high vacuum (UHV).

II. Gratings and Grating Drive

It has been determined that the standard McPherson design of using a cam to correct for focus while scanning wavelengths was acceptable as to precision and operational integrity but would limit future applications entailing the use of gratings with different radii of curvature or line spacing (as variable line space gratings). It was decided that the gratings motions of rotation and translation would be separately and independently adjustable. Computer code controls wavelength and focus, permitting variation of motion combinations.

To avoid complications in finalizing opto-mechanical design, a typical Rowland circle mount grating (spherical, 6.65 m radius of curvature, 4800 G/mm grating) was selected. The dispersion and resolution of this grating were employed in establishing tolerances and range of grating motions and adjustability.

For the monochromator to operate over the 0 to 2000 Å range approximately 950 mm of



translation and 30°

of rotation are required. The accuracy and repeatability of these motions is very critical in high resolution modes of operation. Grating translation accuracy's of 5 um with resolution of 1 um are required. Rotational specifications are even tighter with accuracy's of 0.05 arcsec and resolution of 0.02 arcsec. Absolute rotary and linear encoders combined with low noise stepper drive systems and a real-time interferometer provide the actuation and feedback controls for these motions.

Initial manual grating alignment and adjustment are provided in the roll, pitch and yaw axes. Roll and pitch are adjustable with 150 um resolution and yaw to 30 arcsec (over ± 2°). These adjustment can be made under vacuum conditions permitting in situ optimization of the optical system. Window flanges and feed through are provided so the full range of adjustments can be made safely and efficiently.

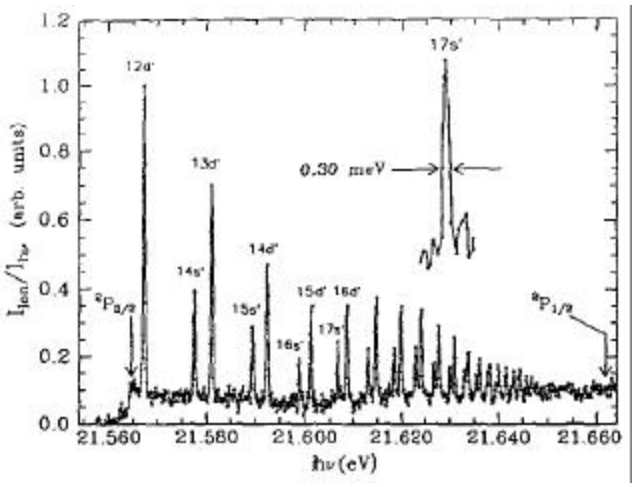
Provisions have been made to maintain two gratings in the optical system and select between the two as required under vacuum. The grating exchange mechanism provides reproducible image position at the exit slit within a tolerance of 20 um. Additionally, provisions for external zero order fine adjustment assure repeatable calibration when using more than one grating. For either installed grating a zero order baffle helps reduces scatter within the system.

III. Slits

The entrance and exit slits of this system are separated by 174 mm (center to center) as determined buy the systems included angle. This dictates that the slit actuation mechanisms of width, height and rotation must be kept compact.

Slit are bilaterally adjustable in both width and height. Width is selectable from 5 to 1000 um, parallelism accuracy's at 5 um are 10%. The resolution on this adjustment is 1 um and readout on precision micrometers is linear. Slit height is variable between 1 mm and 10 mm. The adjustment of height is continuous, actuated by a precision micrometer and also features linear readout.

The off-plane Eagle optical system exhibits the characteristic a slit image rotation. This occurs due to the over under optical geometry and when the wavelengths are scanned. In compensation for this, both slits are provided with an in vacuum adjustable mechanism for accurately rotating the slits over ± 2°, with a resolution of 0.005°. The experimenter is free to optimize for resolution or throughput at any wavelength in the instruments range.



World record resolving power of 72,000 was demonstrated in threshold ionization of Neon using the McPherson Eagle monochromator at the Advanced Light Source.

IV. General

Additional options such as insertable calibration sources, flux monitors and absorption cells have been designed. Depending on the final experimental

configuration, these items can be provided along the instruments long optical path or at the slits. Again, all UHV practices are observed to provide the user with practical and user friendly instrumentation.

McPherson supplies this system with or without optics and vacuum pumping provisions as well as software control. If the user has difficulties in obtaining optics or pumps McPherson tests and demonstrates the system with its own gratings (or 'dummy' optics), pumps and RGA before shipping. We supply RGA certification for all components. We stand ready to address you special requirements or to provide turn key systems.

V. Summary

The described instrument is available as an all metal sealed design. Its UHV compatibility and distinguishing operational characteristics mark it as an ideal high resolution beamline monochromator for any experimental end-station operating in this wavelength range.

The specification have been determined by the experimental and engineering staff of University of California, Lawrence Berkeley Laboratory Advanced Light Source with special mention of P. Heimann, M. Koike, T. Namioka, D. DiGenarro and McPherson, Inc. instrument companies J. DeMarino, J. Nihen, B. Dolan and D. Schoeffel.

Additional information relating to the off-plane Eagle design and applications can be found in:

T. Namioka, "Design of High Resolution Monochromator for the Vacuum Ultraviolet. An Application of Off-plane Eagle Mounting":, J. Opt. Soc. Am. 49, 961 (1959)

P.G. Wilkinson, "A High Resolution Spectrograph for the Vacuum Ultraviolet", J. Mol. Spectrosc. 1, 288 (1957)

M.L. Ginter, D.S. Ginter and C.M. Brown, "Need for High Resolution in VUV Rydberg State Spectroscopy", Appl. Opt. 19, 4015 (1980)

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