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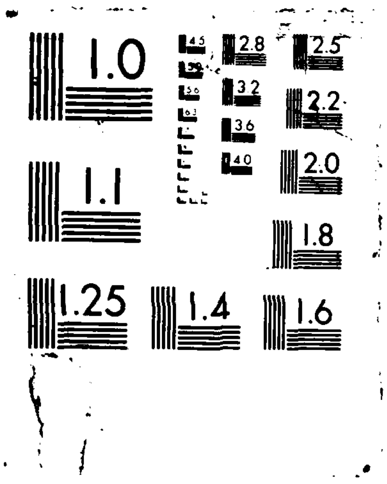
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A vacuum spectrograph and pumping station have been purchased and installed in the Intense Beam Interaction Laboratory at the University of Michigan. Specifically, an Acton Research Corporation Model VM-510 1.0 meter, f/8.7 corrected Czerny-Turner vacuum monochromator with turbo-molecular pump and three gratings (1) 1200 g/mm plane ruled blazed at 500 nm, (2) 1200 g/mm plane ruled blazed at 200 nm and (3) 600 g/mm plane ruled blazed at 400 nm. This instument has been tested and has been used to obtain data on several research projects.

This instrument is being used to study population inversions in ablation plasmas generated by long pulse, intense, relativistic electron beams, a project currently supported by the Air Force Office of Scientific Research (AFOSR 86-0012). This spectrograph

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A vacuum spectrograph purchased from the Acton Research Corporation has been installed and tested in the Intense Beam Interaction Laboratory at the University of Michigan. The total cost was $69,715. The instrumental system consists of the following:

1) ARC Model VM-510: 1.0 meter, f/8.7 corrected Czerny-Turner vacuum monochromator with manual wavelength drive and ARC #1200 Al&MgF_2 coating on mirrors.

2) ARC Model 035: Side port and movable flip mirror for use with standard slit assembly.

3) ARC Model 036: Side port and moveable flip mirror for use with spectrographic attachment. Includes larger optic to provide 2" focal plane.

4) ARC Model 716: Bilaterally adjustable slit assembly (5 microns - 3 mm by micrometer control). Slit height is manually adjustable from 1 - 20 mm.

5) ARC Model 721: Slit chamber vacuum isolation valve.

6) ARC Model 722: Slit chamber air inlet and roughing valve.

7) ARC Model 746: Stepping Motor Scanning System complete with RS-232 compatible indexer, power supply and stepping motor.

8) ARC Model ST-205-10: Pumping system support table with casters, leveling pads and 10" height adjustments.

9) ARC Model TPS-700-360: Turbo molecular pumping system, 360 l/sec, with 14 c.f.m. mechanical pump, N/O venting device, foreline trap and adapter to instrument.

10) ARC Model DA-781-VUV: End-on detector assembly with 2" diameter PMT and sodium salicylate coated window for wavelength conversion.

11) ARC Model 195-020: Adapter flange for Tracor Northern 6132 array.

12) ARC Model 175: 35mm vacuum camera attachment with 2" long focal plane. Includes daylight loading film cassette, multiple exposure capability and hinged vaccum tight access door.

13) ARC Model 175-015: Vaccum isolation, air inlet and roughing valves for Model 175.

14) Grating, 1200 g/mm plane ruled grating blazed at 500 nm

15) Grating, 1200 g/mm plane ruled grating blazed at 200 nm

16) Grating, 600 g/mm plane ruled grating blazed at 400 nm.

Model VM-510 was purchased, not model VM-521-SG as described in the proposal. The reason for the difference is due to a misunderstanding between myself and the manufacturer at the time the proposal was written. Both are one meter spectrographs to be used in the vacuum ultra-violet. However, we also wanted to capability to view the visible (3800 - 8000 A) as well as the ultra-violet (1800 - 3800 A) and vacuum ultra-violet (1100 - 1800 A). Model VM-510 was designed to perform both of these tasks. Also the optics of the Model VM-510 was better suited for use with an optical multichannel analyzer (OMA). We wanted the spectrograph to be compatible with our other optical equipment, especially the OMA. The total cost of the system purchased was the same as the one proposed.

The OMA consists of an array of photodiodes (1024) and computer controlled aquisition system, gatable with pulses as small as 50 ns. This allows for time resolved spectroscopy of a wide range of wavelengths simultaneously. Due the fact that the OMA has a quartz window in its optics, it can only be used on ultra-violet and visible radiation ($>$ 180 nm). Therefore, we also purchased a special photomultiplier tube to be used in the vacuum ultra-violet for the situations where information regarding ultra-violet line emission is desired.

The spectrograph, detector (OMA) and pump have been placed in a lead covered screen room to shield them from electrical noise and from x rays produced by the electron beam accelerators (see Figure 1). This involved re-arranging our small screened room to accommodate the size of the instrument as well as some special wiring of 220 Volt lines for the pumping station. Both the pumping station and the optics were then tested and found to be in working order.

The new spectroscopic capabilities are being used on the project entitled "Population Inversions in Ablation Plasmas Generated by Intense Electron Beams" funded by the Air Force Office of Scientific Research (AFOSR 86-0012). The purpose of this project is to investigate techniques for generating population inversions in ablation plasmas by means of long-pulse, intense, relativistic electron beams. The ultimate goal of this project is to investigate the possibility of using a long pulse, relativistic electron beam as a source for coherent short wavelength radiation as well as to study the physics of particle beams and pulsed power technology.

An example of some data from this project is shown in figure 2. Both spectra are examples of emission produced by carbon ablation plasmas produced by MELBA (Michigan Electron Long

Figure 1. Photograph of the VM-510 and pumping station.

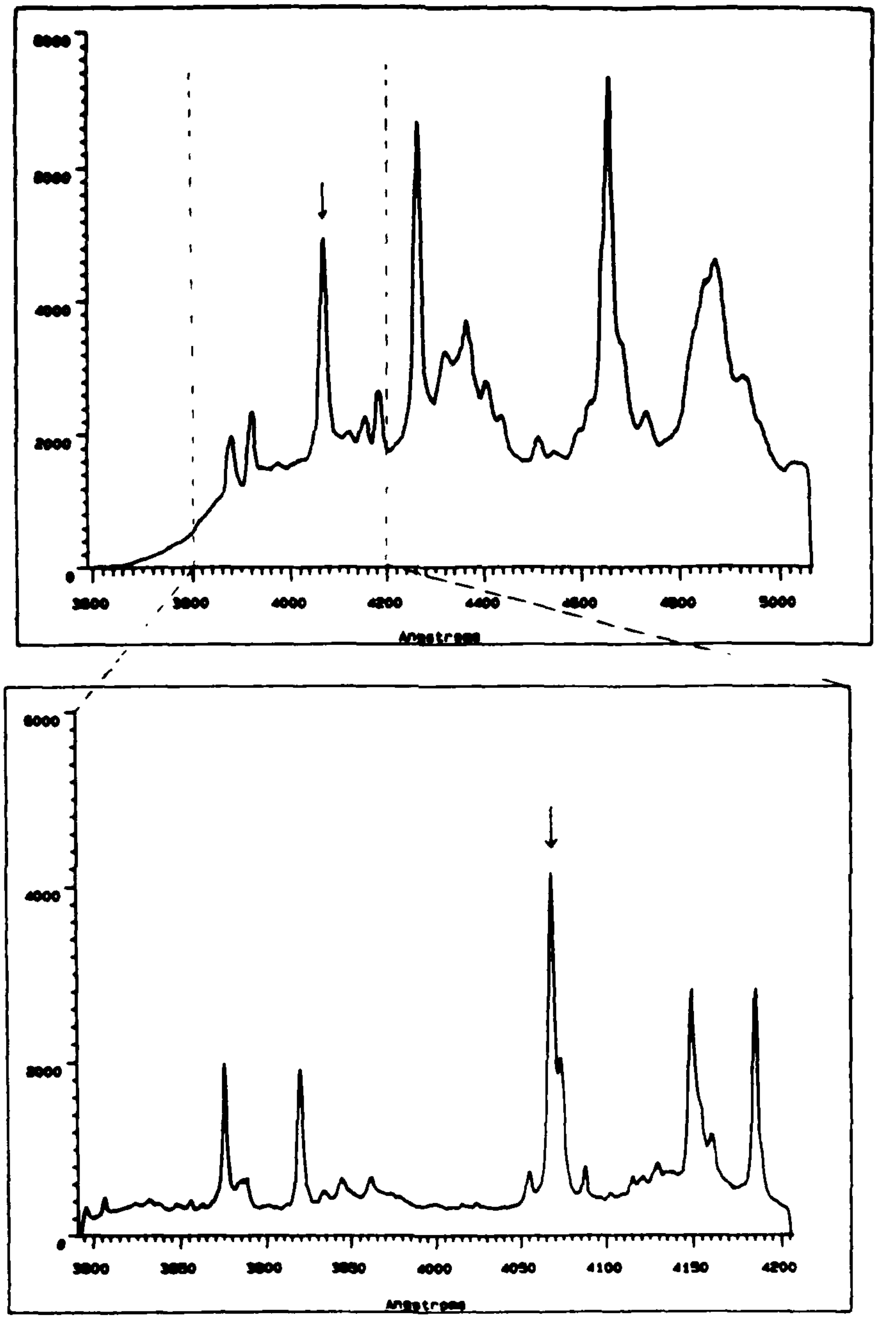

Figure 2. Spectra of carbon ablation plasmas produced by MELBA. Top spectrum was taken with the old 0.275 spectrograph with a 600 g/mm grating. The lower spectrum was taken with the new 1.0 meter spectrograph also with a 600 g/mm grating.

Beam Accelerator). The top figure was taken with an 0.275 meter spectrograph with a grating blazed at 4000 A with 600 g/mm. Note that the dispersion is such that about 1400 A is viewed. The bottom figure was taken with the new 1 meter spectrograph with a grating blazed at 5000 A with 600 g/mm. Because of the longer path length, about 400 A is viewed.

In the top figure, notice the large peak at 4068 A. With the higher resolution of the new spectrograph this large peak is found to be actually four peaks as seen in the lower figure. We had anticipated that the larger amount of dispersion of the new spectrograph would result in lower overall intensities. Although intensities vary from shot to shot, in this case it is seen that the intensity is about the same for the new spectrograph as for the old. We were pleased to find that we gained a great deal of resolution without giving up our good signal to noise ratio.

The greater resolving power has been very important to this project. Now we are able to identify emitted lines with greater certainty. In addition, we are able to determine which lines are due to the anode and which may be due to contamination from the cathode stalk. We are now able to verify that the intense lines are due to one transition, rather than several transitions close together in energy. Also we have observed intense lines in the ultra-violet (1800 - 3800 A) which we were unable to observe before. Also, with the high resolution of the current optical system, we plan to investigate Stark broadening of hydrogen impurities as a means of determining electron density and/or electric field strength. This would not have been possible with the previous system.

This spectrograph will also be used on a project supported by the Office of Naval Research (N0014-85-K-0542). One of the goals of this project is to examine the electromagnetic emission produced by laser/electron beam interactions with reduced pressure gases. The emission spectroscopy of air is particularly complicated and the improved resolution of the new system will be put to great use. By way of example, please note figure 3. The top figure is an example of emission spectra produced by an electron beam induced krypton plasmas at 100 torr. It was taken with the 0.275 meter spectrograph with a grating (1200 g/mm) blazed at 4000 A. The bottom trace was taken from the identical experiment, but using the new 1 meter spectrograph with a 600 g/mm grating blazed at 4000 A. The hidden structure of the peaks in the top figure are easily identified by the new spectrographic system. This greater resolving power is important in identifying the specific energy levels excited by the electron beam. Also, this greater resolution will facilitate the identification of the complex spectra produced by polyatomic molecules.

Emission spectroscopy is one of the few non-invasive diagnostics on intense electron beam produced plasma experiments. This new spectrographic system has greatly improved our capability to detect and identify emission spectra. This will lead to a better understanding of the physics issues in our DOD projects.

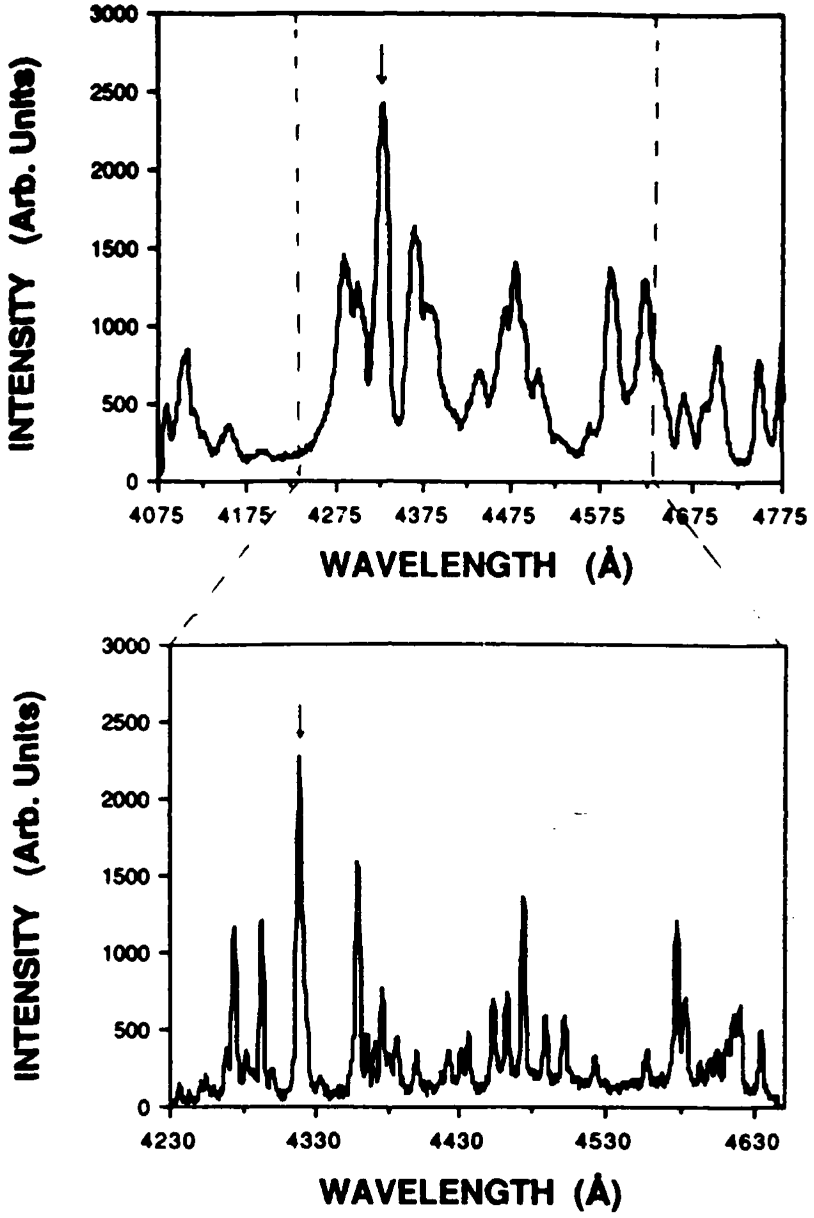

Figure 3. Emission spectra from 100 Torr Krypton, excited by an electron beam (300 keV, 1 kA). The top trace was taken with the old 0.275 meter spectrograph with a 1200 g/mm grating. The bottom trace was taken with the new 1.0 meter spectrograph with a 600 g/mm grating.

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