

## IMAGE PROCESSING FACILITIES AT VAINU BAPPU OBSERVATORY

S.Giridhar<sup>1</sup>, J.C.Bhattacharyya<sup>2</sup>, K.N.Kutty<sup>1</sup>,  
<sup>1</sup>Vainu Bappu Observatory, Indian Institute of Astrophysics,  
Kavalur.

<sup>2</sup>Indian Institute of Astrophysics, Bangalore 560 034.

**ABSTRACT.** Need for application of Image processing techniques in astronomical studies in optical wavelengths and special advantages accruing thereby are discussed. The paper describes various image processing facilities that are being used with Vax-11/780 system at Vainu Bappu Observatory, Kavalur. The use of various software packages and graphics that are being used in connection with different astronomical problems are demonstrated. Preliminary results derived from ultraviolet observations of R Cr B stars using IUEDR package contained in STARLINK software are also discussed.

### INTRODUCTION

Imaging celestial objects was a problem from the very beginning of radio astronomy. The degree of precision in determination of the direction of arrival of radio waves from celestial sources by the early instruments was perhaps comparable to the similar precision with which our skin can detect hot objects in a dark room. Inadequate size of the aperture resulting in poor resolution was the main reason for this shortcoming. The scientists were forced to go deep into the science of image formation and device tricks to bring out essential elements of information. The knowledge thus acquired has found wide applications in many fields, in many bands of radiations, and even in other types of wave motions.

But, that does not mean that in optical astronomy the necessity of image processing was never felt. Basic limitations in detector capabilities were always felt by astronomers of all times. It was realised quite early that something is wrong with our eye; the most sensitive part of the retina is not in the middle, but in the peripheries. That is how the technique of averted viewing became common among old-time astronomers. It was also indirectly recognized that the atmosphere plays havoc with the image of astronomical objects. For double star observers, it became a fine art, how to mentally register the steadiest images and determine

the separation and orientation of the components, even if they are very close.

The advent of photography brought in a revolution in observational astronomy. Major gain was in the ability of integration, a process by which much fainter objects could be studied. But fresh problems were also introduced; photography basically is brute integration; finer tricks of selection of transient image frames could not be applied. In the process of building up of images, all smearings due to seeing, scattering and image movements are added up.

There had been some efforts to process recorded photographic images. Good planetary images in the prespace era were composed by overlaying carefully selected short exposure image. Diffuse masking techniques in removal of scattered background radiation has brought out much sharper pictures. About twenty years ago Labeyrie had suggested speckle interferometry idea; ultra-short-exposure photographs could be processed to yield seeing corrected images.

The situation has now taken a dramatic turn with the availability of solid state detector arrays and on-line computers. Not only the new detectors have much better quantum efficiencies, but they can also provide instantaneous image information. The basically analog information can be digitized very fast, and the array of digital numbers can be numerically manipulated. The extent and variety of these manipulation processes are almost endless; everyday new ideas are being generated and applied in observational programs, which at one time used to be given up as unsolvable.

The CCD detector arrays and television camera type sensors are being experimented with, in our laboratories for almost a decade. The initial tuning of service system of the Vainu Bappu Telescope was, indeed, monitored by a CCD camera sitting at the prime focus. But, for observations at the limits of detection, where the new technique displays unquestionable superiority, it is necessary to operate the detectors under cryogenic conditions. Fabrication of cold chamber for CCD detectors was also attempted with limited success. Two imported systems are available with two research institutions in the country; a few others are expected very soon.

The Vainu Bappu telescope was conceived at the time when these new changes were coming in the observational techniques. To make those techniques of image processing applicable on this telescope, necessary computer hardware was included as a part of the telescope system. The system chosen was VAX 11/780 together with COMTAL image processing hardware. Efforts to adapt some of the already developed software by other astronomer groups in the world and to develop new software to suit special requirement of programs conducted in our observatories are going on there. In the next part of our joint presentation, some details of these equipment and activities are described.

**THE CONFIGURATION OF VAX-11/780 SYSTEM AT  
VAINU BAPPU OBSERVATORY**

The incorporation of the Vax-11/780 system with the telescope covers two intended functions, viz:

i) Precise control of the telescope and ii) on line processing of image information. It is the second function which is critical in the operation of this telescope in the frontiers of present day astrophysical research. The basic configurations of the telescope system are described below:

The physical memory of the system is 3M bytes.

**Disk Drives:** There are two RM05 disk drives with storage capacity of 256M bytes and one RM80 with storage capacity of 124M bytes.

**Magnetic Tape Drives:** TU77 that can read information stored in density (800/1600 bpi) and TU78 for density (1600/6250 bpi).

**Display Terminals:** Colour Monitor, Tektronix 4115B graphic terminal, VT102, VT125, VT240 graphic terminals.

**Printer/Plotter:** Printronics 600 printer/plotter, Tektronics 4691 colour copier.

**Interface between V.B. telescope and Vax:** LPA11-K, Direct Memory Access controller is an interface between the Vax and the telescope control system microcomputer Intel 86/14. CAMAC system interface which is GEC-Elliott executive suite hardware system, would be located at the face of the telescope and would be used to interface the instruments and detectors to the Vax.

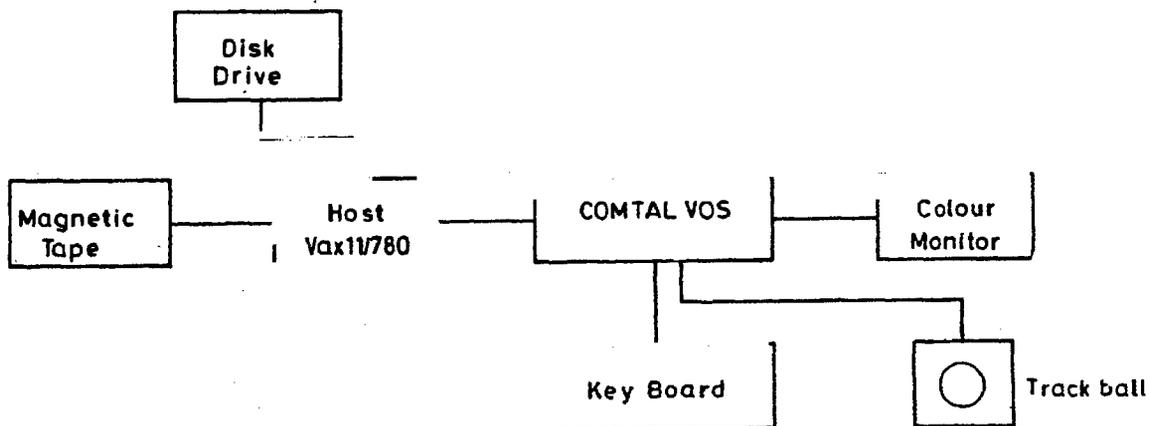


Fig.1. The configuration of Vax-11/780 system at Vainu Bappu Observatory

The basic components of any image processing system are digitizer, processor and display system.

Digitizer converts the image into numerical representation suitable as input to the computer. The most commonly used digitizers are microdensitometers, scanners, Image dissectors, TV Camera digitizers etc. Microdensitometers require the image to be stored on photographic plate or film but are capable of high degree of positional accuracy. A Perkin Elmer PDS model 1010M microdensitometer which is in operation at IIA, Bangalore has a positional accuracy of 5 $\mu$ m. With the aid of the eight different apertures and four different magnifications, one can select pixel sizes over a range of 5-400 $\mu$ m. The microprocessor Z6802 controls the process of digitization and PDS system can measure densities in the range 0-5.11.

#### COMTAL IMAGE PROCESSING SYSTEM

The schematic diagram shows the COMTAL image processing system being used at V.B.O. Kavalur. This system can hold four independent images with each image having a spatial resolution of 512 x 512 pixels and brightness resolution of 8 bits i.e. 256 grey levels. It can also support four graphics that are images with brightness resolution of single bit. The display unit is a colour monitor with screen diagonal size 18". The control commands that are defined in COMTAL software library are typed on a keyboard and the cursor can be brought to any position using the track ball. Comtal Vision One system contains several firmware operations that can be readily applied to an image. Notable among them are independent function memories that can be applied to individual images, colour processing, zooming etc. The contrast of an image can be improved by modifying the function memory which controls the displayed pattern from the stored information. Fig.2 displays improvement brought about in the image of the Sun observed with HeI 10830 Å filter by Jagdev Singh. Using Fourier techniques one can deblur a given image smeared due to turbulence in atmosphere by suitable modelling of noise function and deconvolving the original image with noise function. Fig.3 demonstrates the restoration of an image with Fourier method. Fig.4a demonstrates the rotation of a given image by different angles. Fig.4b displays magnification in two axes by non-integer values using Fourier method. Fig.4c is a 3-d representation with Z axis displaying intensity levels. In Fig.4d the perspective of an image is highlighted by plotting intensity gradients across X axis.

Fig.5 is a picture of Comet Halley in which pixels falling in different intensity intervals are given different pseudocolours to highlight the various features of the image.

#### PLOTTING SOFTWARE AND DEVICES

The VT125, VT240 are graphic terminals with spatial resolution of 767 x 479 pixels, the VT125 being black and white whereas VT240 can display three colours. The ReGIS Graphic Library provides basic commands for plotting. In addition to various types of line patterns, symbols and markers, they can display four shades of grey level which are

represented in VT240 by Black, Blue, Red and Green colours. Fig.6 shows a scan of spectrum of V810 Cen in  $4300\text{\AA}$ - $4800\text{\AA}$  region.

Printronic-600 printer can be used as plotter with pixel size of  $0''.0167$  x  $0''.0138$  with PLXY software, which is again a library of FORTRAN callable routines. Fig.7 is a simultaneous three variable plot, the variables being temperature, Log gas pressure and Log electron pressure plotted as a function of optical depth shown by three different symbols.

Tektronics 4115B display terminal provides a spatial resolution of  $1280$  x  $1024$  pixels over the graphic surface and can display 16 grey levels. The Tektronix Plot-10 series Interactive Graphic Library (IGL) contains a collection of Fortran routines to be used in generating plots on display terminal. With the help of colour copy interface, one can make colour copies of the curves plotted on screen with a 4691 colour copier. The spectrum of Supernova 1987A in LMC plotted using Tektronix terminal is shown in the Fig.8.

**Additional Software:** A software package RESPECT for the reduction of photographic spectra has been developed at IIA (Prabhu, Anupama & Giridhar 1987). A library of scientific subroutines with explanatory notes has been compiled from various sources by Giridhar and Ghosh.

We obtained 1984 version of STARLINK software developed by UK astronomers for image processing and data reduction. The software covers data processing packages for different kinds of data including ultraviolet, optical and infrared observations. Selected portions like IUE data reduction package IUEDR, display and plotting software DIPSO etc have been used so far. Fig.9 contains high resolution IUE spectrum of R Cr B processed using IUEDR package. The figure also contains spectrum of comparison star  $\gamma$  Cyg. The aim of the project was to isolate and study the emission components seen in the absorption cores of strong resonance lines. For the resonance lines of MgI at  $2852.1\text{\AA}$  a P Cygni profile with two absorption components occurring at  $-53$  and  $-171$  Kms<sup>-1</sup> relative to the emission can be easily seen in the difference spectrum plotted at the top portion in Fig.9. The methods of obtaining difference spectrum have been described in detail in another communication (Rao and Giridhar 1986). A study of these emission components and detailed model atmosphere calculation would help in calculating the rate of mass loss in R Cr B.

#### REFERENCES

- Prabhu, T.P., Anupama, G.C. and Giridhar, S. 1987. Bull. astr. Soc. India, (Submitted).  
Rao, N.K., Giridhar, S. 1986, IIA Newsletter 1, No.4, p.26.

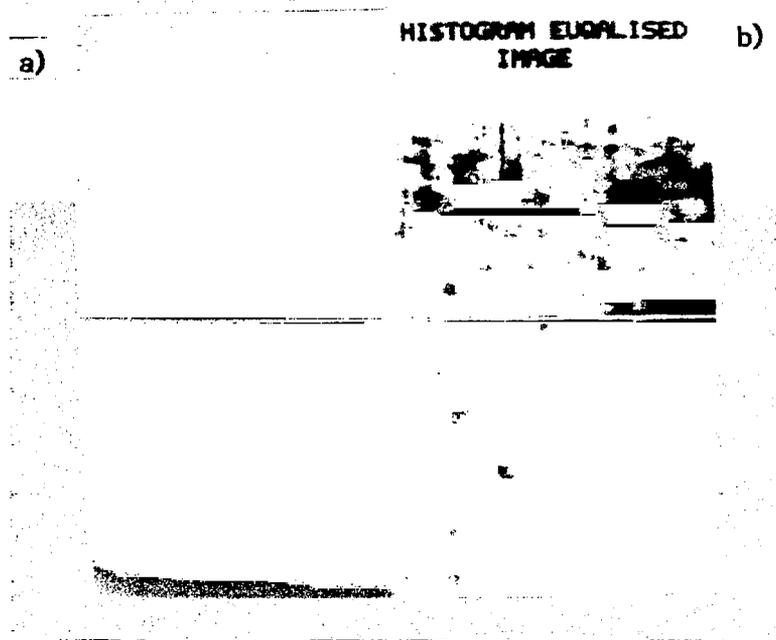


Fig.2. (a) The image of the sun observed with 10830A° filter.  
 (b) The image of the sun improved by histogram equalization.

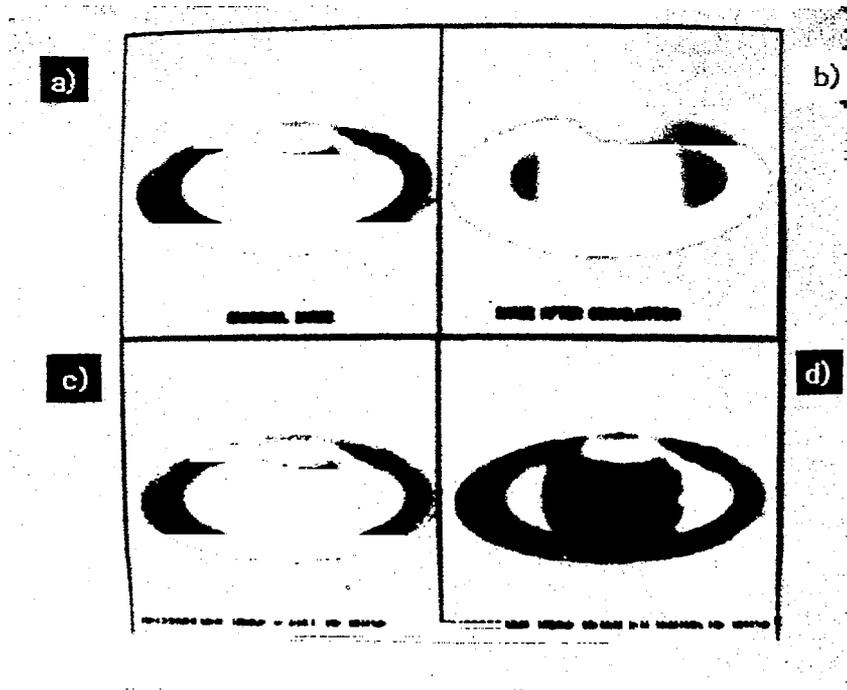


Fig.3. a,b,c,d, Various steps in restoration of a blurred image by Fourier deconvolution.

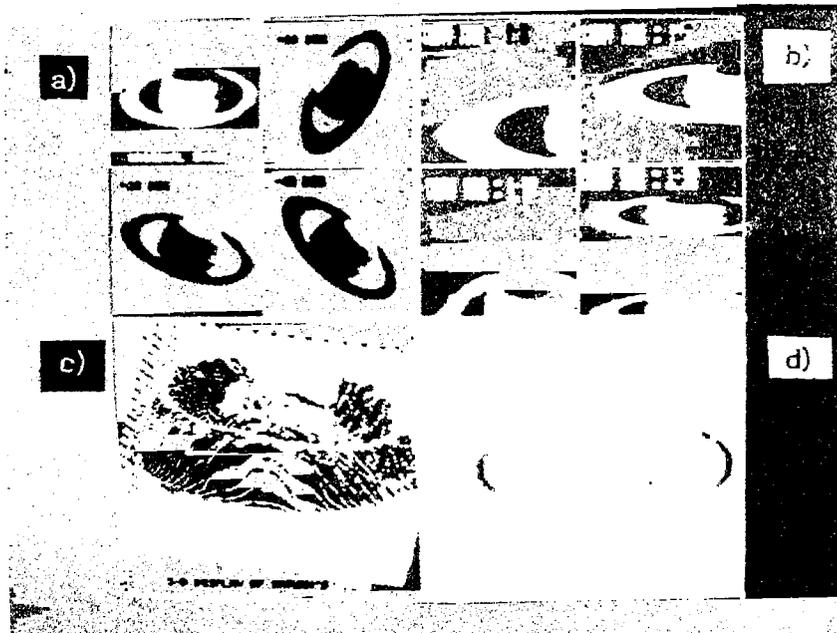


Fig.4. (a) Demonstration of Fourier Technique to rotate an image.  
 (b) magnification by non integer factor.  
 (c) A 3-d representation with Z axis representing intensity levels.  
 (d) Perspective of an image highlighted by showing intensity gradient as a function of x.

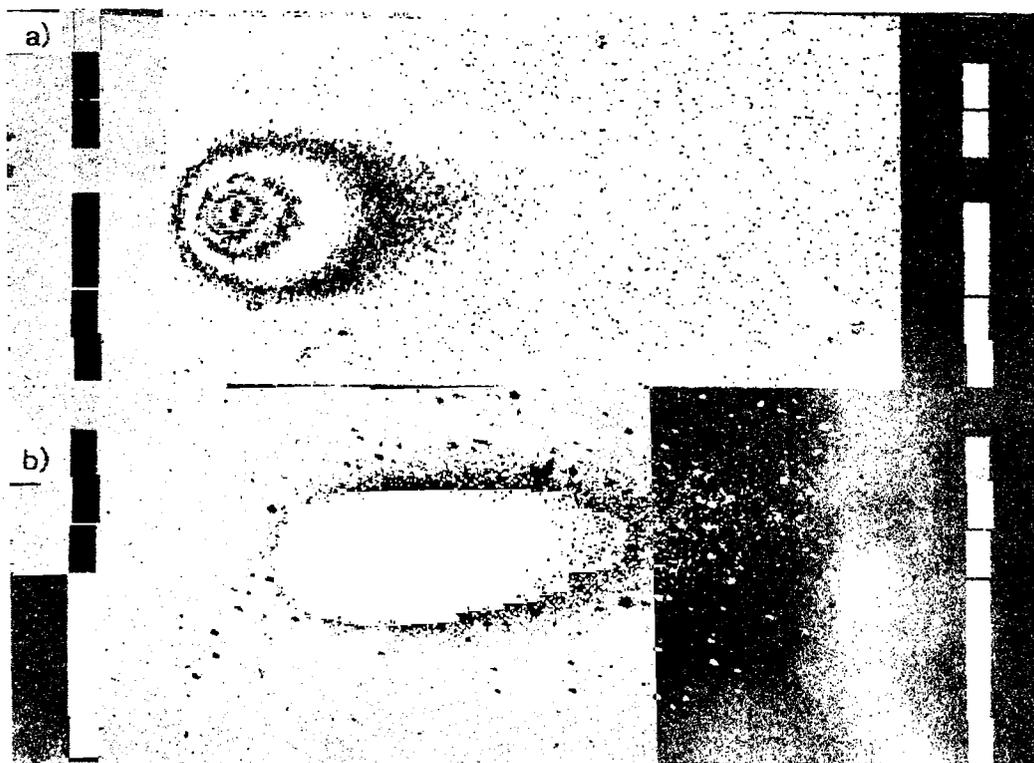


Fig.5. Comet Halley with different Intensity levels given different pseudocolours.

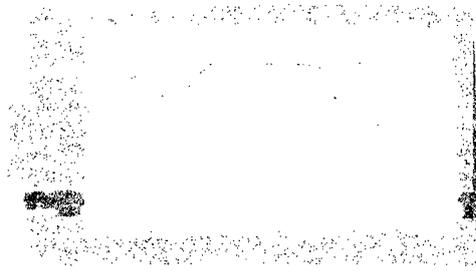


Fig.6. Spectrum of V810 Cen plotted using ReGIS software.

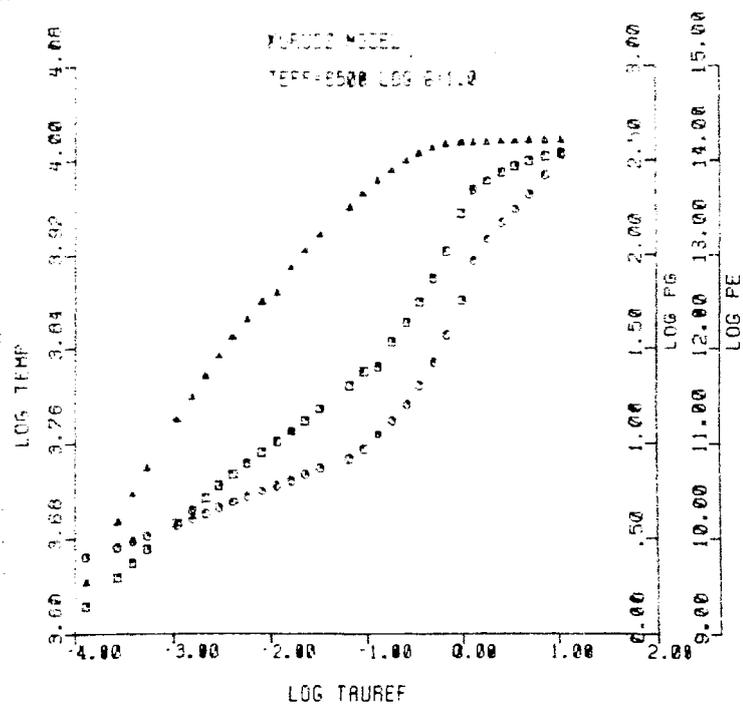
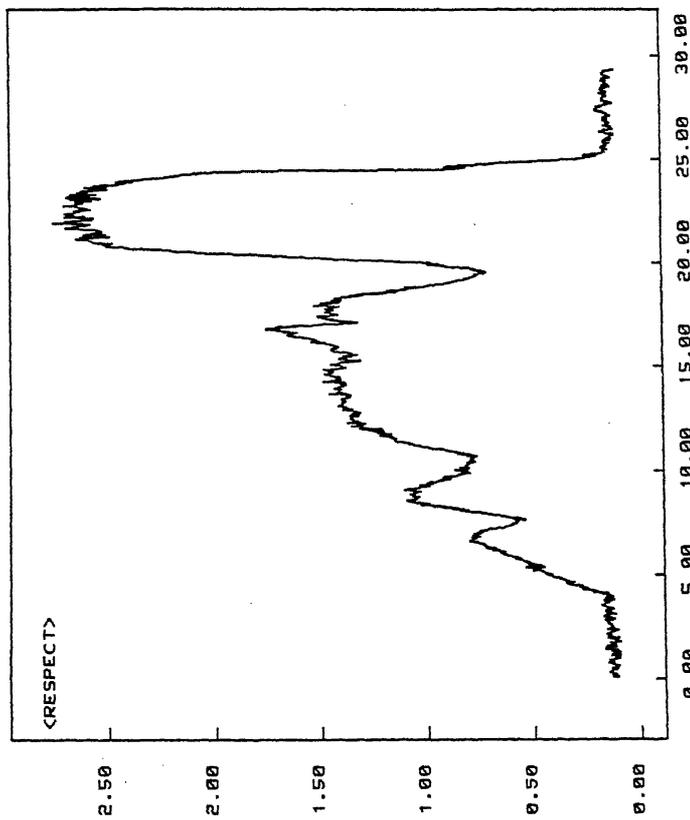


Fig.7. Three variable plot using PLXY software.



SN 1987 IN LMC FEB 26

Fig.8. Spectrum of Supernova 1987A

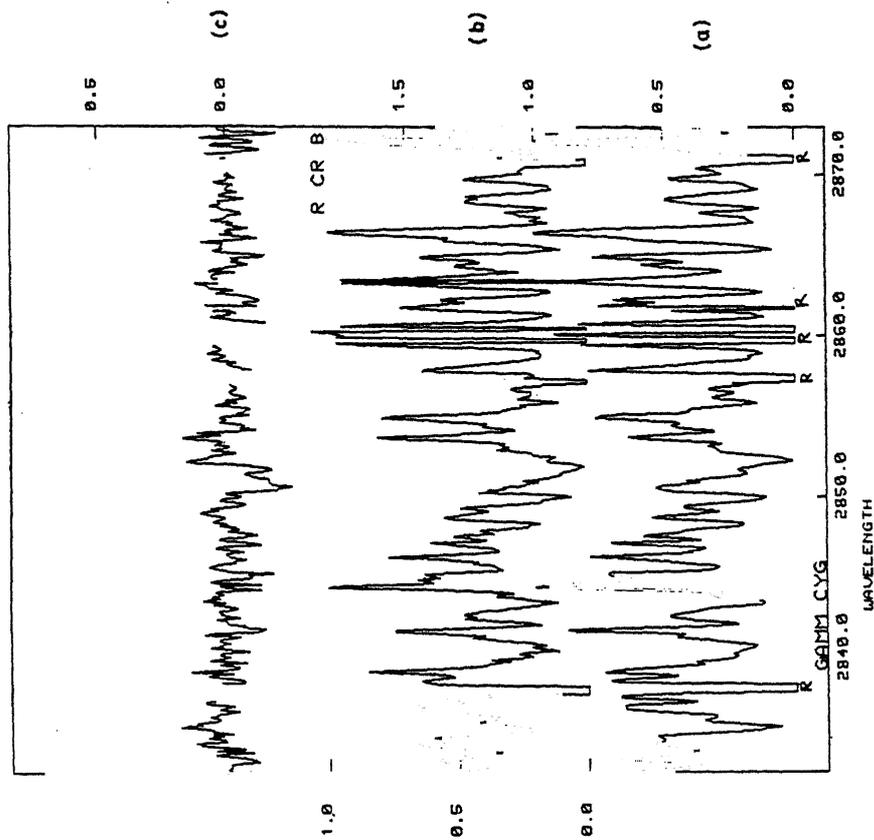


Fig.9. (a) IUE spectrum of R Cr B around 2852A°  
 (b) IUE spectrum of gamma Cyg around 2852A°  
 (c) The Difference spectrum

Courtesy IIA Newsletter