THE IRAF SOFTAWARE SYSTEM AND ITS USE FOR UV - FLUX VARIABILITY STUDIES

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Abstract

The most important characteristics of the Image Reduction and Analysis Facility (IRAF) software system are given and its utilization is illustrated by the flux-variability study in low-resolution IUE spectra of the Be star 59 Cyg.

1 The IRAF software system

IRAF is an extended software system. It has been designed to provide an efficient and portable system for the analysis of images and other classes of data. Although suggested particularly for astronomical images, IRAF has general facilities. Some of the functions that are provided are quite specialized, dealing with the characteristics of specific instruments, but others are generalized functions for plotting data, computing statistics, processing lists and performing other functions that are common to data processing in many other fields.

The project has been accepted at KPNO (Tucson, Arizona, USA) in 1981 and in 1983 IRAF has been selected as the command language and operating environment for the STScI Science Data Analysis System. The IRAF project was benefiting by a continuous support during last years, partly thanks to a direct liaisons with the Hubble Space Telescope project, partly thanks to the increasing use by the space sciences community.

IRAF V2.8, which is the last version, has been distributed since 1989 (for a detailed description see e.g. Tody and Barnes, 1989). The VMS, SunOS3, SunOS4, BSD, Convex, DEC station 3100, X11 (includes Apollo stations), AOSVS and Ultrix versions are available at present time, Alliant and HP versions are being completed. Standard graphic devices as e.g. Printronix plotter, Versatex, HP7550A pen plotter or HP Laser Jet II are supported within IRAF V2.8. More graphic devices are supported particularly by VMS/IRAF versions.

IRAF command language (CL) provides not only an interface between the user and the standard packages of functions but also a programming language to construct new scripts. Utilizing CL the user can control the function parameters, data and system components (e.g. graphic devices). The main standard task packages are as follows. Not all functions that are included in the individual packages are listed in the subsequent overview:

1. CL Intrinsic and Builtin Functions - enables e.g. to set all parameters of a function, to define a new task.
2. System Package Functions - enables to handle data files.
3. General Data Analysis - enables to read and write the data in different formats, to perform one or two-dimensional Fourier analysis, plot and smooth the data.
4. Spectral Analysis - enables to determine the radial velocities, equivalent widths, to carry out a reddening corrections or a spectrophotometric analysis.
5. Time Series Analysis - intended for the Hubble Space Telescope Data.
6. Astrometric Analysis - for an analyses of astrometric data.
7. Cryomap - intended for Cryomap data reduction.
8. Echelle - enables reduction and different manipulations with echelle spectra.
9. Generic - utilities concerning background, bias and flat fields.

10. Images - includes important utilities for the image arithmetics and statistics, averaging, copying and deleting of images.

11. Lists - enables different manipulations with lists.

12. Local - enables to edit images.

13. Multispec - includes some limited modeling of the spectra.

14. Plot - provides different plotting facilities.

15. Softools - includes facilities supporting a creation of new user programs.

16. TV - image - facilities enabling a pseudocolour mode, zooming, windowing.

17. Utilities - calculations of the air mass at a given elevation and of the proper exposure time, manipulations with the text files.

2 Flux variability studies using IUE spectra

The IRAF system was not originally intended for reductions of IUE spectra. A new tasks, which enable to examine and manipulate IUE high-dispersion echelle spectra, are only being developed. However, the up-to-date facilities provide a powerful tool to analyze the low-dispersion IUE spectra. Nevertheless, IRAF system was not used for this purpose so far.

We have used the low-resolution spectra of the Be star 59 Cyg taken by the IUE satellite in the period Dec 1978 - Jun 1984. 24 spectra have been taken with the short-wavelength camera (SWP) and 22 with the long-wavelength (LWR or LWP) camera. All spectra have been extracted from the IUE Uniform Low Resolution Archive, Version 2.0 (ULDA; Wamsteker et al. 1989). The extraction of the spectra was carried out at the Astronomical Department, University of Trieste using VAX 750 computer. Analysis of the data was done at the Center for Advanced Research in Space Optics (CARSO), Trieste using the Sun 4/110 computer and the IRAF software system, version 2.8.

We have developed a new and efficient way how to search for a flux variability in the IUE spectra using the IRAF standard utilities. All spectra have been rebinned to obtain the flux values for the same wavelength grid. The rebinned points have been calculated using a polynomial function of the 5th order. The wavelength step (about 1.18 and 1.87 Å for the SWP and LWR/LWP spectra respectively) coincides with the mean step used for the low resolution IUE spectra processed with the software implemented at VILSPA on March 10, 1981. The original wavelength step of the spectra obtained before this date was about two times smaller. The mean spectra have been calculated for the sets of SWP and LWR/LWP spectra, it means, we have calculated average flux and sigma values for each wavelength point. Plots of the sigma values as the functions of λ then illustrate the flux variability through the entire studied wavelength region. Using the mean spectra and sigma plots we fixed the wavelength intervals, which are the most appropriate for a study of flux variations in the continuum. Statistical analysis in these intervals was carried out using the standard IRAF utilities. It gives mean fluxes and magnitudes and their statistical characteristics.

Our results show that the UV-fluxes of the studied star are strongly variable and the amplitude decreases towards the longer wavelength. It is about 39 % of the flux value at 1450 Å, it means near the flux distribution maximum, but only about 17 % for $\lambda > 2800$ Å. At a rough approximation the flux variations are parallel in all chosen bands. A more detailed results of our 59 Cyg study will be given elsewhere.

Acknowledgement: The author thanks to the University of Trieste and to the Center for Advanced Research in Space Optics, Trieste, that supported his stay in Trieste in the Autumn 1989 and kindly provided their facilities for his use.

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