Far Ultraviolet Imaging with the FAUST Telescope

Abstract

The Far Ultraviolet Space Telescope (FAUST) flew on the Space Shuttle in March 1992 and obtained 22 wide-field images covering about 3% of the sky in the wavelength range 1400-1800 Å. We discuss the advantages and difficulties we have encountered while doing wide-field imaging in the far ultraviolet (FUV). We have measured and cataloged approximately 4000 FUV sources. Our photometric measurements of these sources are found to contradict TD1 FUV measurements and are currently being used to refine current UV stellar population models. We have encountered difficulty in performing measurements of the diffuse astronomical background because of geocoronal airglow present in our wavelength band. Our studies of these data are continuing.

1. Introduction

The Far Ultraviolet Space Telescope (FAUST) was designed to do wide-field (7.6° diameter) imaging of diffuse and point astronomical sources at wavelengths between 1400 and 1800 Å (Deharveng et al. 1979; Lampton et al. 1990). FAUST is distinguished from other instruments that have operated in this wavelength range, such as the Hubble Space Telescope and the Ultraviolet Imaging Telescope on Astro-1, by virtue of its extremely wide field. Prior to its latest flight in March 1992 on board the Space Shuttle, the instrument was upgraded to include a photon-counting wedge and strip microchannel plate detector (Lampton et al. 1986; Siegmund et al. 1987) in place of an intensified film camera. During the recent flight, we obtained 22 images, covering a range of targets and galactic latitudes. The complete list of targets is given in Bowyer et al. (1993).

2. Point Sources

A variety of environmental and geophysical backgrounds are seen in the data and must be eliminated as part of the data reduction process (Lampton et al. 1993). These include shuttle attitude control thruster firings, twilight, nightglow, auroras, and South Atlantic Anomaly passages. Our photon-counting, time-resolved data system makes it possible to eliminate these time-dependent backgrounds.

We scanned the resulting images for point sources and found over 4,800 above 3σ. Most of these were below the threshold of the all-sky ultraviolet survey made by the TD1 satellite (Gondhalekar et al. 1980). Where there was overlap between FAUST and TD1 sources, we discovered a significant discrepancy between the fluxes measured by each instrument. Since no such discrepancy was present in a similar comparison between FAUST and IUE, we have concluded that the TD1 fluxes have a larger error than has been published. (For a complete discussion, see Bowyer et al. [1993]).

A detailed study of the far ultraviolet (FUV) stellar population in the area of the North Galactic Pole is underway (Brosch et al. 1993). This work compares the number of stars seen as a function of magnitude with the model of Brosch (1991). Preliminary results are that more FUV stars are present in the image than are predicted by this model, yielding intriguing options as to the identity of these sources.

3. Measurements of the Diffuse FUV Sky

An important component of the FAUST observational program was to measure diffuse astrophysical sources. Topics include measuring the diffuse ultraviolet glow at many different galactic locations as a tracer of interstellar dust and the UV radiation field, mapping dense regions in the interstellar medium (ISM), and measuring the extragalactic background ultraviolet light. Additionally, FAUST made downlooking observations of Earth's nightglow (described in Chakrabarti et al. 1993). In Fig. 1, we show the FAUST image of the Ophiucus region, one of the densest parts of the ISM. This image shows clearly variations in the diffuse emission, as well as a number of point sources (in fact, we have identified more than 300 stars in this field.

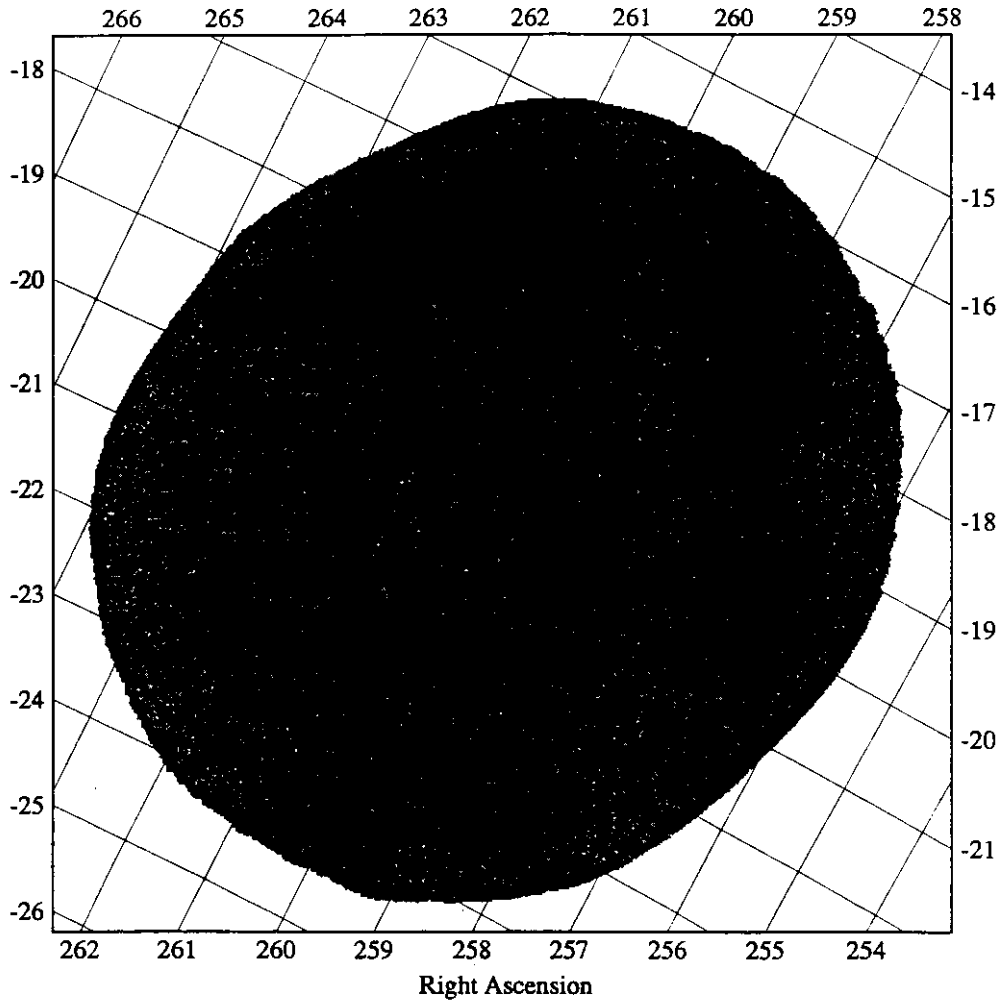

Figure 1. FAUST image of Ophiucus, with coordinate grid (in degrees) superimposed. Obscuration of starlight is clearly visible, caused by dust and gas in this region.

From our studies of the nightglow and a careful comparison with other measurements of the UV astronomical background (Hurwitz et al. 1991; Bowyer et al. 1991), we have concluded that FAUST measures a higher baseline level of UV diffuse flux than previous measurements. We show in Fig. 2 FAUST measurements of the diffuse background as a function of atomic hydrogen column. Also plotted are the measurements of Hurwitz et al. (1991). These data show factor of 2-3 difference between the two measurements. One of the clues to the origin of this excess emission comes from FAUST's operation during a period of high solar activity compared to some of the earlier measurements. We attribute the excess flux seen in the FAUST images to recombination emission from atomic oxygen, which has emission lines within our bandpass. The presence of this emission in our images makes absolute flux measurements uncertain but does not preclude differential measurements within an image.

4. Conclusions

In summary, the wide-field images made with the FAUST camera have provided sensitive measurements in the far ultraviolet of diffuse and point sources. Stellar observations sample a substantially different population of stars than are seen at optical wavelengths, and present a new window towards complete galactic population studies. Studies are underway of the diffuse emissions measured by FAUST. These sensitive diffuse observations are complicated by the presence of nightside airglow from the upper atmosphere.

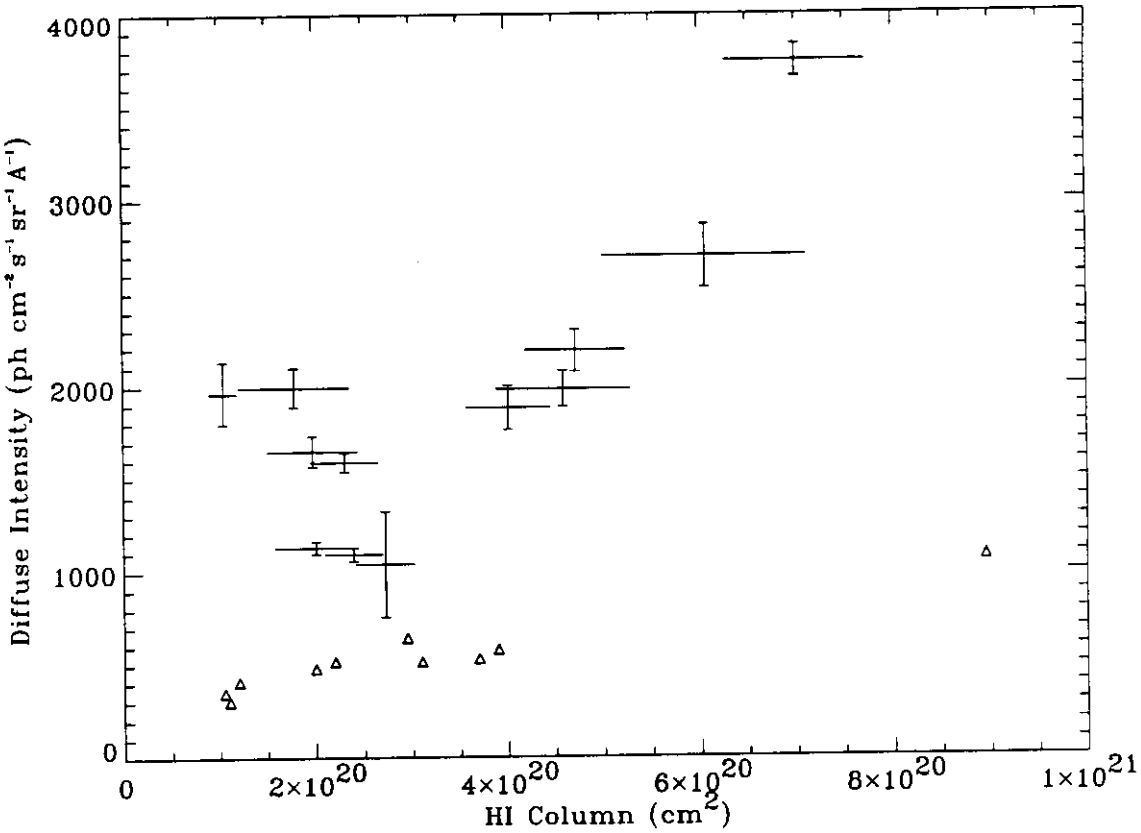

Figure 2. Diffuse intensity measured by FAUST vs. HI column. The bars show standard deviation of variation of column and diffuse intensity over field of view. Triangles are measurements of Hurwitz et al. (1991). FAUST measurements are higher because of residual airglow in images.

Acknowledgements

This work is supported by NASA contract NAS8-32577. Stuart Bowyer acknowledges support from the John Simon Guggenheim Memorial Foundation.

References

Bowyer, S., 1991. "The Cosmic Far Ultraviolet Background", *Ann. Rev. Astron. Astrophysics.*, **29**, 58.

Bowyer, S., Sasseen, T.P., Wu, X. and Lampton, M., 1993. "In-Flight Performance and Preliminary Results from the Far Ultraviolet Space Telescope (FAUST) Flown on ATLAS I", *Astrophys. J.* Submitted.

Brosch, M., 1991. "A Model of the Galaxy in the Ultraviolet", *Mon. Not. R. astron. Soc.*, **250**, 780.

Brosch, N. Almoznino, E., Heller, A., Mash'al, E., Goldberg, Y., Leibowitz, E.M., Netzer, H., Sasseen, T.P., Bowyer, S., Lampton, M., Wu, X. and Hurwitz, M., 1993. "FAUST Observations of the North Galactic Pole". In preparation.

Chakrabarti, S., Sasseen, T.P., Lampton, M. and Bowyer, S., 1993. "Observations of Terrestrial FUV Emissions by the FAUST Telescope", *Geophysical Res. Letters.* Submitted.

Deharveng, J.M., Riviere, G., Monnet, G., Moutonnet, J., Courtes, G., Deshayes, J. and Berges, J., 1979. "FAUST Instrument: A High Focal Ratio Telescope for Far and Near UV Imagery", *Space Science Instrumentation*, **5**, 21.

Gondhalekar, P.M., Phillips, A.P. and Wilson, R., 1980. *Astron. Astrophys.*, **85**, 272.

Hurwitz, M., Bowyer, S. and Martin, C., 1991. "The Albedo and Scattering Phase Function of Interstellar Dust and the Diffuse Background at Far-Ultraviolet Wavelengths", *Astrophys. J.*, **372**, 167.

Lampton, M., Deharveng, J.M. and Bowyer, S., 1990. "Imaging the Large and Small Scale Structures of the Far Ultraviolet Background with the FAUST Instrument", IAU Symposium 139, eds. S. Bowyer and C. Leinert, p 449.

Lampton, M., Siegmund, O.H.W., Bixler, J. and Bowyer, S., 1986. "A Position Sensitive Microchannel Photomultiplier for UV Space Astronomy", *Proc. S.P.I.E.*, **627**, 383.

Lampton, M., Sasseen, T.P., Wu, X. and Bowyer, S., 1993. "The Diffuse Shuttle Ultraviolet Foreground", *Geophysical Res. Letters.* In press.

Siegmund, O.H.W., Lampton, M., Bixler, J., Vallerga, J.V. and Bowyer, S., 1987. "High Efficiency Photon Counting Detectors for the FAUST Spacelab FUV Payload", *IEEE Trans. Nuc. Sci.*, NS-34.

*Timothy P. Sasseen, Stuart Bowyer *, Xioayi Wu and Mike Lampton*
Center for EUV Astrophysics
University of California
Berkeley, CA 94720
** also with Astronomy Department*
University of California
Berkeley, CA 94720
U.S.A.

A CCD-based Sky Patrol

On December 11 1992 an informal meeting about 'A European Large Wide-field Telescope' took place, chaired by R. West, at the Garching ESO Headquarters (see page 41 of this Newsletter). During the meeting we mentioned briefly the past and recent activities of the Sonneberg Sky Patrol and the need for a modern CCD-based patrol which monitored the whole sky. Through this Newsletter we would like to introduce the concept of an international joint project and to invite discussion.

1. Definition of Sky Patrol

In the last Newsletter (MacGillivray 1992), West gave a short overview about sky surveys and patrols. To make clear what we mean by 'sky patrol' let us first give our own definition:
A sky patrol aims to record, as often as possible, all the sky that is visible from an observing site down to a certain magnitude in one or more optical or near-optical wavelength regions.

This definition emphasises the contrast to a sky survey, which aims to cover the full sky once or twice and goes very deep, is carried out at high resolution, and may also be multi-coloured. Sky patrols cannot go so deep because of the time needed to cover the sky and on account of the huge amount of data produced. "As often as possible" means every clear night or even shorter up to about once a month. In a sense a sky patrol can be seen as a sequence of regularly performed sky surveys. Multi-coloured sky patrols are desirable but hardly feasible because it would entail an increase of the data bank and the number of cameras needed, or a decrease in the frequency of monitoring.

2. Sky Patrols Past and Present

A sky patrol — like any scientific observational programme — aims at a particular field of interest. This includes objects with more or less rapid changes, mainly variable stars in general (variable in magnitude) and solar-system objects like comets and asteroids (variable in position and magnitude).

From Tsvetkov's article (Tsvetkov 1992) concerning wide-field plate archives, it appears that most sky patrols began in the first decades of this century. The largest archives based on an extended sky patrol are the Harvard Collection, going back to 1889, and the Sonneberg Plate Archive, to 1926.