DIFFRACTION SPIKES AND FAINT TARGET/BRIGHT NEIGHBOR OBSERVING

WITH THE IUE

K. Carpenter, R. Stencel, J. Pesce - CASA/University of Colorado
A. Brown - JILA/University of Colorado
P. Judge, C. Jordan - Oxford University, England

In preparation for our attempt to detect circumstellar UV emission scattered off the extended outer atmosphere of Alpha Orionis, we used a shift of discretionary time (OD14Y) to explore the near-aperture scattered light characteristics of the IUE. The major result of this exploration is a dramatic reminder of the importance of the diffraction spikes, caused by the spider supports for the secondary mirror in the telescope, in any such work.

The observations made during the OD14Y program included low resolution observations, through the large aperture, of three regions slightly offset from the M2 supergiant Alpha Orionis. For all three settings the star was placed completely outside of the aperture, and exposure times far shorter than those required to detect actual circumstellar light, but long enough to detect some telescope scattered light (at least on the edge of the aperture nearest the star), were used. The parameters of the exposures are given in Table 1.

TABLE 1
OD14Y Observations on 1 March 1987

Image #	Delta-X FES units	Delta-Y FES units	Delta-R arcsecs	Delta-edge arcsecs	Exp. time minutes
SWP 30418	-9	-45	11.9	7.0	30
LWP 10237	-9	-45	11.9	7.0	30
SWP 30419	+9	+45	11.9	7.0	30
LWP 10238	+9	+45	11.9	7.0	30
SWP 30420	+49	-10	13.0	3.0	25
LWP 10239	+49	-10	13.0	3.0	5

"Delta-X" and "Delta-Y" are the distances of the star in FES units from the center of the large aperture, along the X and Y FES coordinate axis. "Delta-R" and "Delta-edge" are the distances of the star in arcsecs from the center and from the nearest edge of the aperture, respectively. The star is near one of the flat edges of the aperture in the first four exposures and near one of the rounded edges in the last two exposures. The SWP images were taken during the time the LWP camera was being readprepped in the off-chance that the scattered and/or circumstellar light was much stronger than expected. However, the images were indeed blank, except for some background Lyman-alpha emission, as anticipated.

The LWP images did show significant signal, but it was not distributed as originally anticipated. We had assumed that the telescope scattered light would produce a bright bulge at the point in the aperture closest to the star and that that light would gradually fade out with increasing radial distance from the star, with an $r^{-2.5}$ falloff as given in ESA-IUE Newsletter 25, p. 12 (1982). Although this was approximately the case for the last image, in which the star was outside the rounded edge of the aperture, it was clearly not true for the other two LWP images in which the star was displaced along the short axis of the aperture (in the dispersion direction). In these images the distribution of the monochromatic light from the Mg II 2800 A feature was radically different. In both cases the entire aperture was filled with light, although it was clearly brightest at a point at nearly the same FES X coordinate as the star and mid-way across the aperture in the radial direction from the star. Thus the light maximum was offset from the center of the LGAP, in opposite directions along the long axis of the aperture, in LWP 10237 and LWP 10238. Intensity contour plots and surface plots of the photometrically corrected versions of the three LWP images, in the region of the Mg II 2800 A lines, are shown in Figure 1.

We believe that the broad characteristics of these images can be explained by examining the precise positioning of the star with regard to the aperture and the resulting locations of the diffraction spikes. Figure 2 is a diagram showing the positions in FES-coordinate space of the large aperture, the star, and the diffraction spikes for each of the three images. The diffraction spikes are 6 bright lines of light extending radially out from the star at 60 degree intervals, with the brightest spikes being those along the +/- Y direction. From this figure, it is clear that the main spike crosses through the aperture for the first two LWP images, while in the third position only a (less bright) secondary spike just clips the corner of the aperture. In the latter case we thus see a light distribution more typical of the smooth inter-spike scatttered light. Note that the main spike passes on opposite sides of the aperture center (along the x-direction) in the first two LWP images, thus explaining the mirror-image behavoir of the light distribution in those two images. The brightest point in each image lies on one of the diffraction spikes. The large degree to which the aperture is filled in the first two images indicates a non-trivial width to the primary diffraction spike.

We have also examined the region near Lyman Alpha in the SWP spectra acquired during this shift. Although there is no appreciable amount of Lyman Alpha light from the star (even when it is directly in the aperture), we do of course see the combined geocoronal plus interplanetary Lyman alpha filling the aperture in these 30 minute exposures. We show the photometrically corrected data in this region for the first two SWP images in Figure 3, for comparison to the Mg II data in Figure 1. The size of the region covered by the Lyman Alpha and Mg II light (in the first two LWP images) is similar indicating that the Mg II light does indeed nearly fill the large aperture in those images. Note the double-peaked structure in both of the SWP images, which suggests that the basically flat geocoronal signal is slightly depressed in the central regions, perhaps by camera fatigue in this heavily used region of the detector. J. Clarke (1987, private communication) has noted a change with time in the response of IUE to diffuse Lyman alpha emission, with a trend toward a depression of the central region of the aperture image in later spectra.

ACKNOWLEDGEMENTS

We thank Y. Kondo for allocating the Discretionary Observing Time needed to carry out this investigation and the IUE Resident Astronomers and Telescope Operators for their invaluable assistance in planning and executing the observations. The use of the Goddard RDAF and the GHRS VAX in the production of the figures (using IDL) is gratefully acknowledged.

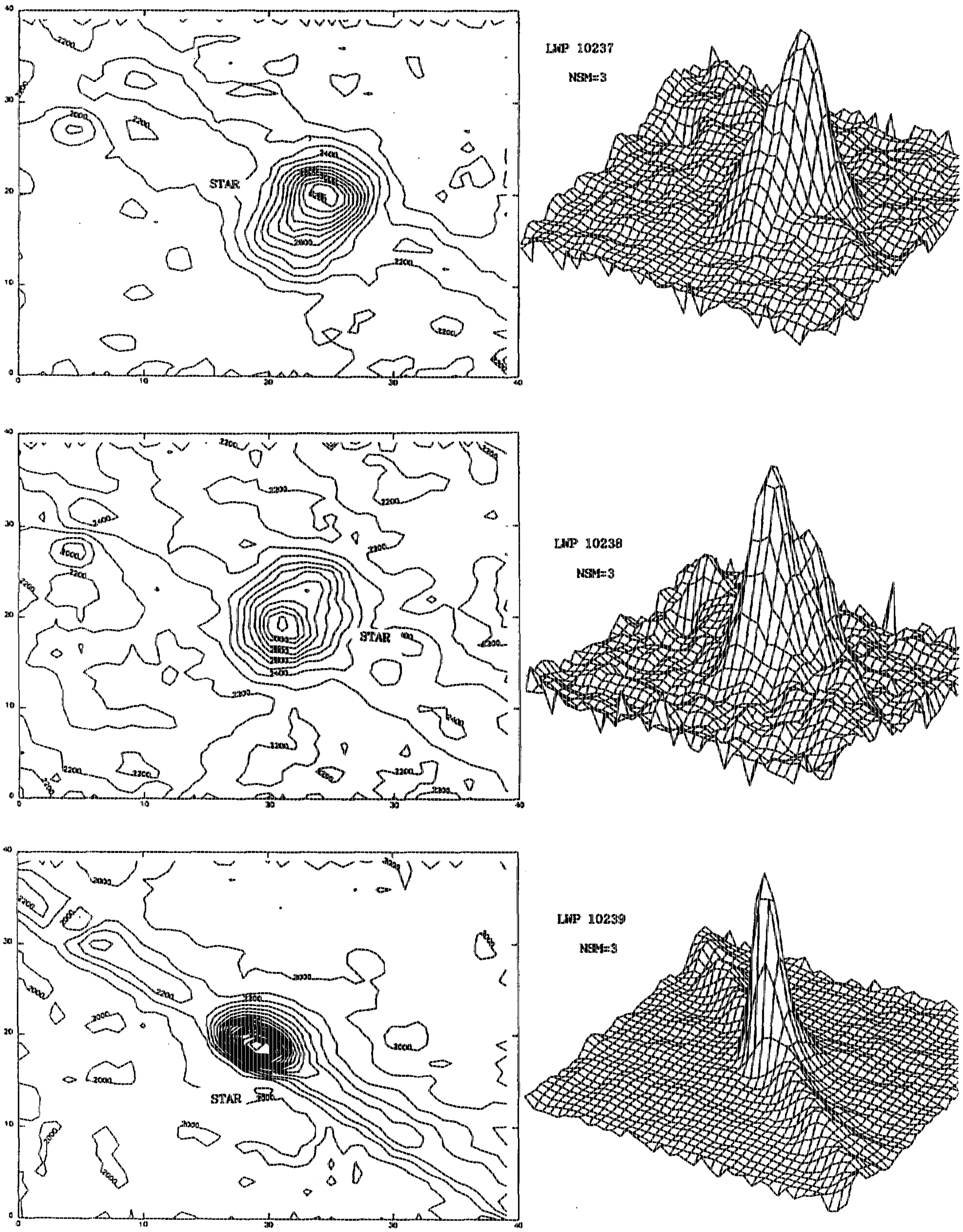

Figure 1: Intensity contour and surface plots, in IUE Flux Numbers, of the region around the 2800 A Mg II lines in the photometrically corrected versions of 3 LWP low resolution IUE images. The location of the star, relative to the Mg II aperture image, is shown on the contour plots. The surface plots are in the same orientation. The direction of dispersion runs from upper left to lower right in each frame.

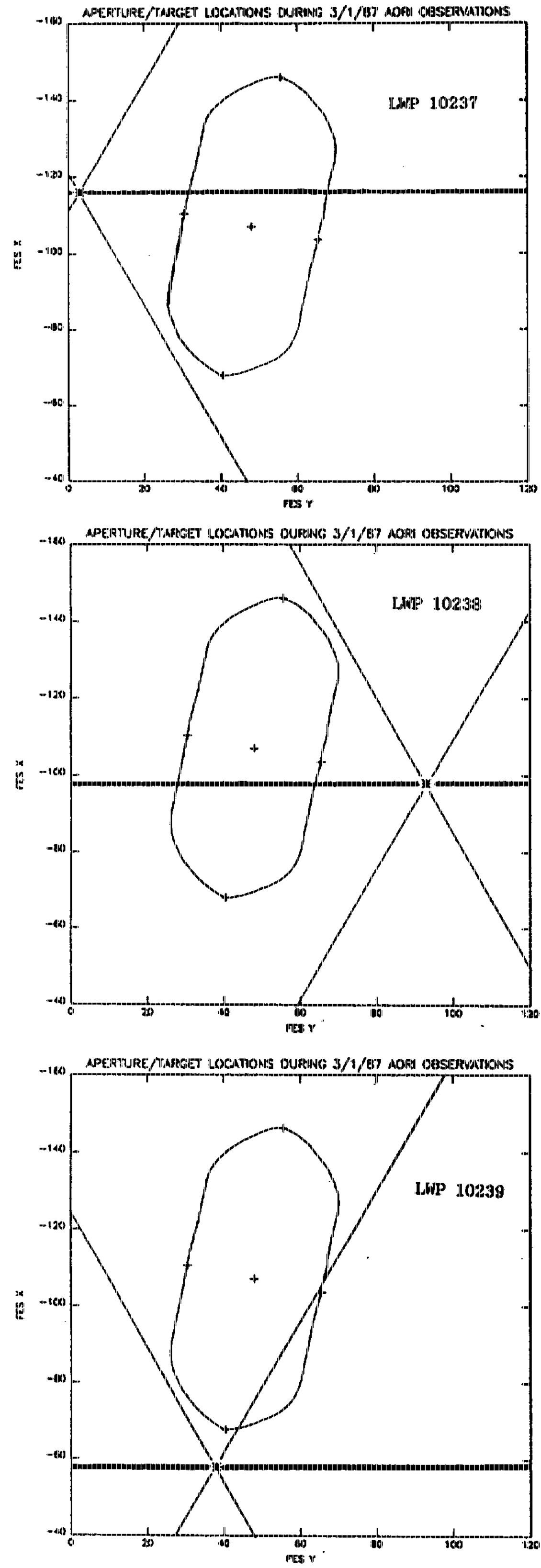

Figure 2: A diagram showing the location of the large aperture, the star, and the secondary mirror spider-support diffraction spikes in the FES coordinate frame for each of the three exposures in Figure 1. These plots must be rotated clockwise approximately 45 degrees to line up with those in Figure 1.

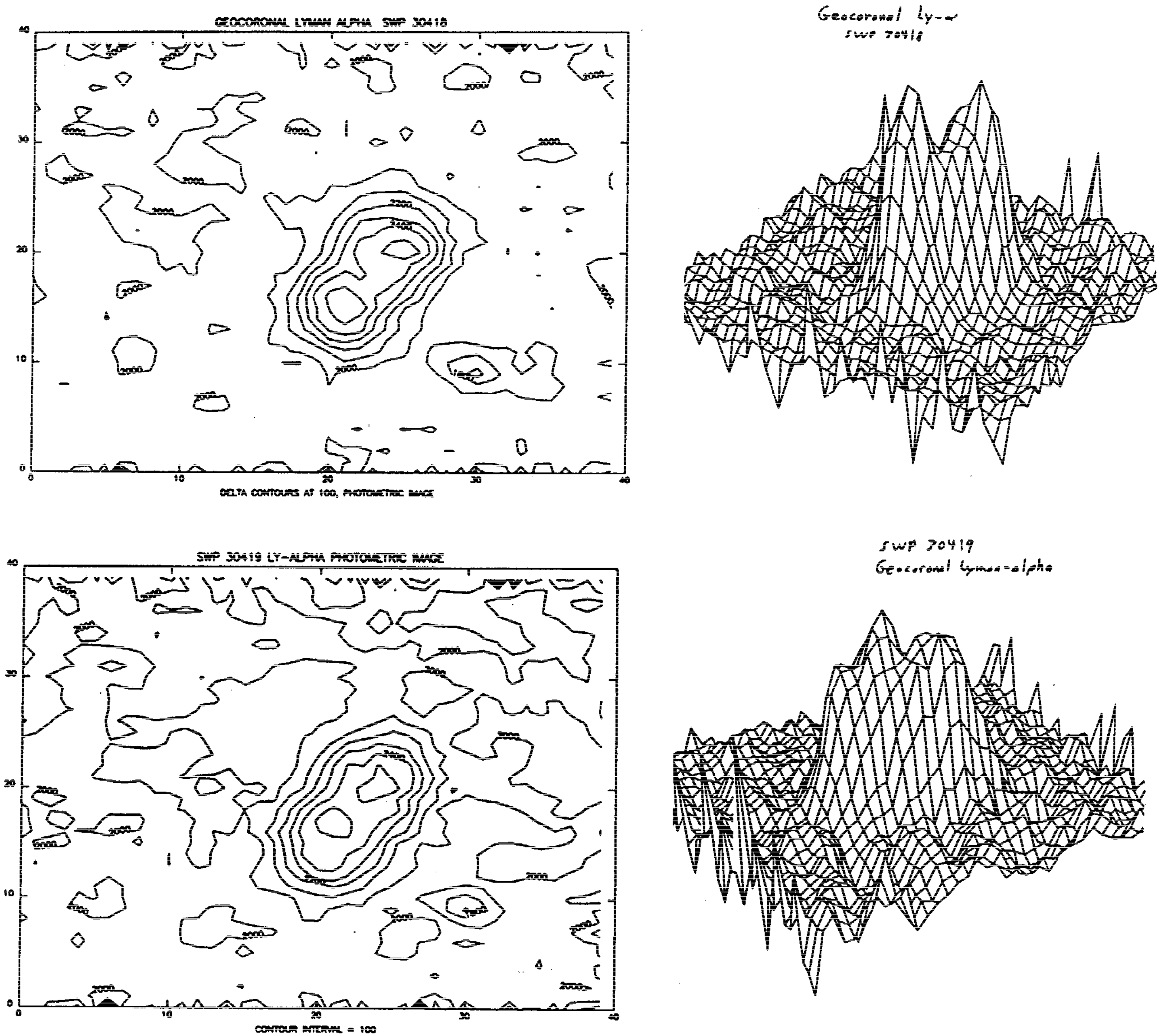

Figure 3: Intensity contour and surface plots, in IUE Flux Numbers, of the region around the geocoronal Lyman-Alpha feature in the photometrically corrected versions of two SWP low resolution IUE images.