# The Goddard High Resolution Spectrograph Status; Absorption Lines in 3C 273

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The Goddard High Resolution Spectrograph (GHRS) is an ultraviolet spectrograph developed by the Goddard Space Flight Center and constructed by the Ball Aerospace Systems Group. The basic performance characteristics are given in Table 1. The detectors are Digicons with an approximately 500-diode linear array; the faceplate/photocathode combinations are LiF/CsI for Side 1 and $MgF_2$/CsTe for Side 2. The two science apertures are 2 x 2 and 0.25 x 0.25 arc seconds square. The GHRS has several undispersed-light modes for target acquisition.

**TABLE 1 -- GHRS BASIC PARAMETERS**

SIDE 1

| GRATING | RESOLUTION | WAVELENGTH COVERAGE (Å) |
|---|---|---|
| G140L | 2,000 | 1050-1800 |
| G140M | 20,000 | 1050-1700 |
| ECH-A | 100,000 | 1060-1700 |

SIDE 2

| GRATING | RESOLUTION | WAVELENGTH COVERAGE (Å) |
|---|---|---|
| G160M | 20,000 | 1200-2000 |
| G200M | 20,000 | 1600-2400 |
| G270M | 20,000 | 2200-3200 |
| ECH-B | 100,000 | 1700-3200 |

In mid-July 1991, we believed that the GHRS was fully functional with only minor problems. This was important because the GHRS was relatively unaffected by the effects of the spherical aberration. Specifically, although roughly a factor of 4 increase in exposure time was required to get the same signal-to-noise ratio as would have been achieved without the aberration, the use of the 0.25 x 0.25 arc second aperture yields the full spectral resolution of the instrument. While our ability to observe the faintest targets, or targets with bright neighbors is reduced, most scientific programs could still be carried out, as shown by the 11 "First Results" papers in the 10 August 1991 issue of **The Astrophysical Journal Letters.**

We will briefly describe the results of one of these papers below.



*J. Bergeron (ed.), Highlights of Astronomy, Vol. 9,* 467–470.

Unfortunately, this happy state of affairs did not persist. By late July 1991, it became apparent that the low-voltage power supply on Side 1 was functioning only intermittently. As a result, operations on Side 1 were suspended. Operations on Side 2 were possible if the low-voltage power supply was able to sustain a science data interface device.

Recovery of reliable use of Side 2 could result from an understanding of the intermittency, or, if this is not possible, switching to an alternate spacecraft data bus. Recovery of Side 1 can be achieved by replacing the low-voltage power supply during the first servicing mission in the 1994 time frame. If COSTAR is also installed in the first servicing mission, the GHRS will have greatly-improved efficiency and we should see a stream of high-quality scientific results as illustrated by the work described in this paper and the other GHRS papers in this volume.

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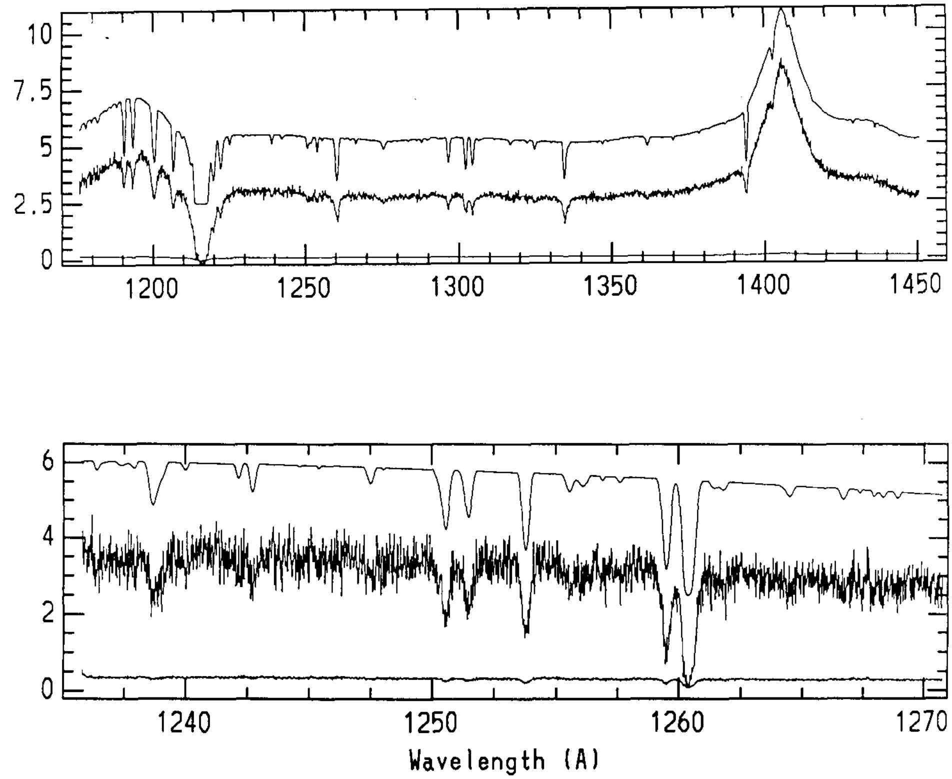


Fig. 1 (above) 3C 273 G140L exposure, raw data (lower curve) in flux units ($F_\lambda$) of $10^{-13}$ ergs cm $^{-2}$ s $^{-1}$ Å$^{-1}$. The deconvolved spectrum (upper curve) has been shifted upward by 2.5 x 10 $^{-13}$ (below). A G160M exposure.

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Study of the "local" part of the Lyman-$\alpha$ forest requires observations from above the atmosphere because red shifts at low values of z are insufficient to move the Lyman-$\alpha$ line into the visible part of the spectrum. Thus, the GHRS spectra of 3C 273 by Morris et al. (10 August 1991 **Astrophysical Journal Letters**, p. L21) had the potential for discovery and we were not disappointed.

The GHRS G140L and G160M spectra of 3C 273 are shown in Fig. 1. The spectra contain many absorption lines from gas in the disk and halo of the Milky Way Galaxy; after these are identified, 16 lines remain that have no plausible identification other than Lyman-$\alpha$ absorption lines with red shifts between 0 and 0.156. Of the 16 lines, 10 are considered certain, 4 are considered possible, and 2 are excluded from the analysis.

The number of absorption lines is at least 4 times greater than expected from extrapolation of the ground-based results; this concept is shown in Fig. 2. In particular, note that the number of lines at $z=0.16$ is not significantly different from the number of lines at $z = 2.10$. This suggests a decrease in the rate of thinning of the Lyman–$\alpha$ forest at $z \sim 2$ or less.

This basic result has also been found by observations taken with the FOS; see the paper by Bahcall et al. (10 August 1991 **Astrophysical Journal Letters**, p. L5).

The explanation for the "forest" of absorption lines in quasar spectra was given in 1971 by C.R. Lynds (**Astrophysical Journal Letters**, v. 164, p. L73) as being due to hydrogen clouds along the line of sight to the quasar. The hydrogen clouds could be isolated, or they could be in the halos of galaxies along the line of sight. Some Lyman-$\alpha$ forest lines have absorption lines from metals at the same redshift, but the lines reported here are faint and detection of associated metals lines is unlikely.

Thus, the Lyman-$\alpha$ clouds exist to zero redshift. This result has the remarkable implication that these tenuous hydrogen clouds have either survived or been continuously regenerated over a Hubble time. The appropriate explanation should prove to be an interesting "cosmological challenge".

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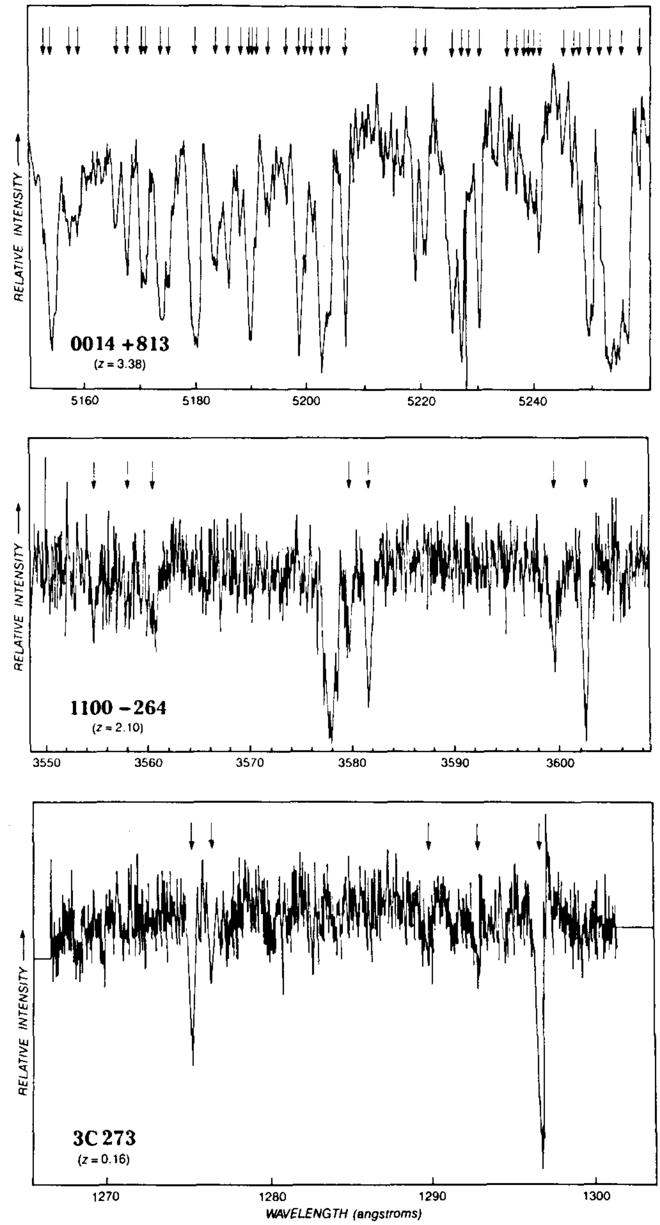


Fig. 2 -- Comparison of Lyman-α forest at different red shifts. The arrows mark individual absorption features. (Original figure from S.L. Morris via **Sky & Telescope.)**