

Summary of GHRIS Documentation at STScI and a GHRIS Bibliography

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ABSTRACT

This ISR lists all the documentation about the GHRIS that is known to exist at STScI, together with its disposition. The most important of these are available to users on-line. Copies of paper-only documents have been provided to the STScI library for archival purposes.

1. Introduction

The Goddard High Resolution Spectrograph was onboard *HST* when it was launched in April, 1990, and was withdrawn from *HST* during the Second Servicing Mission, in February, 1997. Those almost-seven years of operation produced an abundance of observations, which are preserved in the Hubble Data Archive, and scientific results, which have appeared in the astronomical journals and in many conference proceedings. The operations were marred only by the significant loss of capability suffered by the failure of the Side 1 power supply in 1991, and by the unfortunate total loss of the instrument that occurred only one week before SM2, due to a burned-out component. The GHRIS had its heritage in the *International Ultraviolet Explorer*, led to its replacement, the Space Telescope Imaging Spectrograph (STIS), and, at the time this is written, will have some of its body parts preserved in the Cosmic Origins Spectrograph, which is planned for installation in *HST* in 2002.

An instrument is useless to its users without documentation to describe how it was built, what the data look like, how they should be reduced, and so on. The purpose of this ISR is to record the documentation that is known to exist about the GHRIS. This is being written in September, 1997, at the end of STScI's formal support of the GHRIS. Archival Researchers (ARs) will be able to query STScI, but for the most part they will need to be self-sufficient as those who have supported the GHRIS assume other responsibilities.

2. Instrument Science Reports

Instrument Science Reports (ISRs) are technical papers issued by STScI that summarize, for example, calibrations, or new operating features. Approximately 90 GHRIS ISRs have been written. Sometimes ISRs are helpful because they provide details not available elsewhere, but in general we have tried to encapsulate the contents of ISRs into the Data Handbook to the greatest extent possible so that ARs will not need to refer to them. There are some cases where the ISR treats a specialized subject that is beyond the scope of the DH, and note was made of those in the DH as appropriate.

ISRs Available On-Line

The following Instrument Science Reports can be found on the GHRIS web page in several convenient forms. They are listed in reverse order by number, title, and date of issue.

- 090 Redetermination of Sensitivity for Echelle-B, 09/97
- 089 Summary of the Post-COSTAR Side 2 Sensitivity Monitors for GHRIS, 09/97
- 088 Redetermination of Sensitivity for Echelle-A and G140M, 07/97
- 087 GHRIS Cycle 6 Calibration Close-Out, 07/97
- 086 GHRIS Cycle 5 Calibration Close-Out, 07/97
- 085 Redetermination of Sensitivity for Grating G140L, 05/97
- 084 Implementation of a Background Count Rate Model for the GHRIS, 05/97
- 083 The Far Wings of the GHRIS PSF, 09/97
- 082 Analysis of Detector Calibrations for the GHRIS for Cycles 4, 5 and 6, 05/97
- 081 An Analysis of Pipeline Wavelength Calibrations for the First-Order Gratings of the GHRIS in Cycles 4 Through 6, 05/97
- 080 Offsets in Wavelength Between the Large and Small Science Apertures of the GHRIS, 02/97
- 079 Interpreting GHRIS Target Positioning, 02/97
- 078 Multi-Orbit CVZ GHRIS Observations and the Temperature of the Pre-Amp, 10/96
- 077 Anomalies in the Calibration of GHRIS Grating G270M, 10/96
- 076 Photocathode Granularity Maps for Grating G140L of the GHRIS, 08/96
- 075 Summary of the GHRIS Calibration Program During Cycle 4, 05/96
- 074 GHRIS Monitoring Calibrations in Cycle 6, 05/96
- 073 Short-Term Variations in GHRIS Response: An Investigation into an Apparent Anomaly, 05/96
- 072 A Review of the Utility of SPYBALs, 11/95
- 071 Stability of the GHRIS Sensitivity During Cycle 4, 06/95
- 070 GHRIS Dark Noise Monitoring, 02/95
- 069 Stability of the GHRIS Side 1 Sensitivity, 11/94
- 068 FOS-Assisted GHRIS Target Acquisition, 11/94
- 067 Calibration Product Review for the GHRIS in Early Cycle 4, 11/94
- 066 Comparison of the Low-Resolution Mode of the GHRIS and the High-Resolution Modes of the FOS, 07/94

- 064 "LOCATE=EXTENDED": A New Capability for GHRIS, 5/94
- 063 Line Spread Functions and Resolution for GHRIS-LSA Spectra with COSTAR, 4/94
- 062 First Measures of Sensitivity for the Post-COSTAR GHRIS, with Interim Values for Data Analysis, 4/94
- 061 Flux Correction Factors for Pre-COSTAR Observations of Extended Sources with the GHRIS, 3/94
- 060 GHRIS Cycle 2 Sensitivity Monitoring Program 4124, 3/94
- 059 SMOV Proposal 4258: Pre-COSTAR Baseline Sensitivity, 1/94
- 058 An Assessment of the Pipeline Wavelength Calibrations for the Side 2 Echelle Grating of the GHRIS (Ech-B) in Cycles 2 and 3, 1/94
- 057 SMOV Proposal 4757: Light Path Verification, 1/94
- 056 An Evaluation of the Performance of SSA ACQ/PEAKUPS, 11/93
- 055 Line Spread Functions for GHRIS Spectra with the LSA (Pre-COSTAR), 11/93
- 054 Dark Count Statistics for GHRIS Detectors: A Test of Noise Rejection with FLYLIM, 11/93
- 053 Using SPYBALLs to Improve Pipeline Wavelength Calibrations for the First Order Gratings of the GHRIS, 11/93
- 052 An Assessment of the Pipeline Wavelength Calibrations for the First-Order Gratings of the GHRIS in Cycle 2, 11/93
- 051 GHRIS Relative Sensitivity Monitoring, 8/93
- 050 SSA PEAKUP Test-Part 1, 7/93
- 049 Review of the GHRIS 'Double Locate' Strategy, 7/93
- 047 4462: a follow-up on GHRIS ISR 044, 4/93
- 046 LSA Return-to-Brightest Test, 11/92
- 045 Controlling Background Noise for GHRIS Observations: CENSOR, 11/92
- 044 SSA Spiral Search Tests Results for Centering and Throughput, 10/92
- 043 Cycle 1 Detector Calibrations, 10/92
- 042 Trends in GHRIS Far-UV Sensitivity, 10/92
- 041 Cycle 1 Dark Noise Monitoring, 9/92
- 040 Predicting GHRIS Target Acquisition Count Rates, 7/92
- 039 The Accuracy and Repeatability of Pipeline GHRIS Wavelength Calibration, 6/92

ISRs Available Only on Paper

The following may be accessed through the STSci library:

- 065 GHRIS Calibration Plan for Cycle 4, 7/94
- 048 GHRIS Calibration Plan for Cycle 3, 6/93
- 038 GHRIS 3385b: Relative Sensitivity Monitor, 6/92
- 037 GHRIS Bright Star Target Acquisition After the Side 1 Loss, 1/92
- 036 GHRIS 3385: Absolute Sensitivity Monitor, 2/92
- 035 Wavelength Calibration of GHRIS: Analysis of Side 2 Data (Proposals 2844 and 2845), 8/91
- 034 GHRIS Photocathode Flat-Field Maps, 7/91
- 026 Analysis of GHRIS Proposal of 3021: Wavelength Accuracy and Stability, 11/90

Other ISRs

Although written at STScI, we are not aware of copies of the following that exist:

- 033 Preliminary Analysis of Best Focus for GHRIS, 8/90
- 032 Deconvolution of Simulated HST Spectra. II Extension to Variable PSF and New Techniques, 7/90
- 031 Deconvolution of Simulated HST Spectra, 7/90
- 030 Preliminary Analysis of GHRIS Resolving Power Loss Due to OTA Spherical Aberration, 6/90
- 029 GHRIS Photocathode Granularity Calibration, 3/90
- 028 GHRIS STSDAS Tasks, 6/90
- 027 Calibration of the Photometric Sensitivity of Some Low and Medium Resolution Gratings, 2/91
- 025 HRS Signal to Noise Ratio, 4/85
- 024 Planning on Board Target Acquisition with the HRS, 4/85
- 023 Estimated HRS Responses for Optical Throughput Test, 3/85
- 022 Review of Radiometric Calibration of the HRS, 12/84
- 021 HRS Echelle Formats, 12/84
- 020 Proposed Standard Substepping Patterns, 12/84
- 019 Observing Time Required for HRS Echelle Atlases of Zeta Oph and Tau Sco, 12/84
- 018 HRS Platinum Lamp Atlas Medium Resolution, Gratings 2,3, and 4, 7/84
- 017 HRS Flight Software Slew Calculations, Accuracies and Scaling, 7/84
- 016 HRS Display for June 1984 AAS Meeting, 5/84
- 015 System Description and User's Handbook for the HRS, 3/84
- 014 A Gas Absorption Cell for Spectrograph Scattered Light Measurements, 4/84
- 013 Readout Time Overhead for HRS Science Observations, 4/84
- 012 Identification of the Echelle Order Number for Reduction of HRS Data, 3/84
- 011 Y Deflection Offsets of Echelle Interorder Measurements, 2/84
- 010 HRS Paired Pulse Corrections Using A Two-Parameter Fitting Function, 9/83
- 009 Diffuse Scattered Light Associated with the Digicon Front End, 8/83
- 008 Design and Performance of the HRS Sensor Subsystem, 8/83
- 007 Time Constants for the HRS Paired Pulse Correction, 8/83
- 006 Variation of Image Brightness in Acquisition Mode N1, 8/83
- 005 UV Grating Performance in the HRS, 8/83
- 004 Laboratory Test Results on the HRS, 8/83
- 003 Y Deflections for the HRS Echelle Modes, 8/83
- 002 Flight Software for the HRS, 8/83
- 001 Brightness of HRS Acquisition Mode Images at Various Photocathode Locations, 8/83
- A009 Calibration of the HRS Y Deflection Function, 4/85
- A008 Analysis of HRS Point-Spread Functions, 4/85
- A007 Calibration of the HRS Carrousel Function, 3/85
- A006 Calibration of the HRS Paired-Pulse Effect, 1/85
- A005 Post-Refurbishment Calibration Plan for the HRS, 11/84

A004 Review of SE-06 HRS Calibration Algorithms, 3/84

A003 HRS Intermediate Calibration Report, 1/84

A002 Wavelength Calibration for the HRS I Spectral Formats, 12/83

A001 Provisional Radiometric Calibration of the HRS, 11/83

3. Other GHRIS Documentation

Instrument Handbooks

The Instrument Handbooks (IHs) are the single most useful references about the GHRIS except for the Data Handbook. They are essential reading for those who are unfamiliar with the instrument and its capabilities, and want to know what kinds of data may exist. The IHs describe the instrument's operating modes, both generally and in detail, and provide details on constructing observational strategies. Thus the IHs are critical for understanding why a series of observations may have been obtained in the manner they were at the particular time they occurred. The flight software and operating procedures for the GHRIS changed continually over its life as errors were corrected and new features installed. The IHs provide an indication of the history of these efforts (as do the ISRs, described below), which can be helpful in understanding a sequence of observations.

Eight GHRIS Instrument Handbooks (IHs) were issued by STScI between October, 1985, and June, 1995. The first four versions (1.0, 2.0, 2.1, and 3.0) exist as paper-only documents, and they pertain to the pre-COSTAR instrument. The last four versions (4.0, 4.1, 5.0, and 6.0) are available on-line as pdf and html files, and were written for the post-COSTAR instrument.

The IHs contain information that is pertinent to specific time periods and Cycles of *HST* operation, as follows

Table 1. GHRIS Instrument Handbook Versions

IH version	Date of Issue	HST Cycle
2.0	May, 1989	1, 2
3.0	January, 1992	3
4.0	January, 1993	4
5.0	May, 1994	5
6.0	June, 1995	6

Previous Data Handbooks

The Data Handbooks issued by STScI have been evolutionary in their content, and so there is little or nothing in earlier volumes that is not also in the present edition.

Older Documents

We mention here some older documents about the GHRIS that exist only on paper. Copies of these can be found in the STScI library, although researchers should not ordinarily need to review them.

Science Verification Report

Issued by Ball Aerospace Group in February, 1992, the SV Report provides details on the operating characteristics of the GHRIS and describes how these characteristics were measured. We believe that the essential portions of the SV Report have been provided here or in the IHS.

Pre-Launch Calibration Report

Prepared by Ball for GSFC and dated March, 1986, this document contains results from pre-flight calibration tests. These results formed the basis for the first IHS.

HRS Intermediate Calibration Report

Dated January, 1984, this is similar to the Pre-Launch Calibration Report but is less comprehensive.

SE-01

The full title of this document is “SI System Description and User’s Handbook for the High Resolution Spectrograph (HRS) for the Space Telescope (ST) HRS-2176-050C (SE-01).” It was issued in October, 1985, and was a comprehensive pre-flight explanation and description of the instrument. Most of the information in SE-01 has been superseded by later documents that contain on-orbit measurements. On a few rare occasions we have gone back to SE-01 to find information on operating characteristics that was not otherwise available, but that was only for observation execution, not data analysis. Researchers should need this document only under extraordinary circumstances.

Orbital Verification Test Report

The OV Test Report was issued in May, 1992, and describes each of the programs that were executed to verify the successful operation of the GHRIS after the launch and deployment of *HST*. The OV Report is strictly a technical document and does not contain information of use to researchers.

Orbital Verification Data Analysis Plan

This was issued in May, 1990, at the time of *HST*’s launch, and describes the complete technical details for the tests that were planned at that time to check on the performance of

the GHRIS. This is also a strictly technical document that contains no information needed by ARs.

A&V Thermal Vacuum Test Report

This was prepared in two volumes: A, Scientific Performance, and B, Functional, Operational, and Engineering Performance. These reports were issued in November, 1986, and describe results from pre-flight tests that were made to simulate orbital conditions as part of *HST*'s Assembly and Verification (A&V). Again, these are strictly technical.

Ball System Engineering Reports (SERs)

These documents are short descriptions of specific tests and calibrations executed during the Science Verification (SV) period, and they are numbered from GHRIS-SV-001, issued in November, 1990, to GHRIS-SV-134, issued in April, 1994. These documents formed the basis for the SV Report described above, and so their contents have been distilled and saved. A few of the later ones in this series were incorporated into later documents.

A similar series of SERs was issued after SM1 as GHRIS-SMOV-0001 to -0010.

Related Documents

Some other documents exist that can be helpful in understanding a set of observations and why they may have been taken in the form they were.

Phase II Proposal Instructions

This document provides the details and rules for the use of all modes of *HST*'s instruments. It was generally issued once per Cycle, and two versions exist for each edition: a General Observer version and an engineering-only version. The latter version contains information on instrument modes that are normally used only for calibration or test. Under some circumstances a researcher may wish to more fully understand some calibrations. If the needed information cannot be found in the GO version of the Phase II Proposal Instructions, we recommend that you contact STScI (help@stsci.edu) for further assistance.

TRANS Scripting Guide

This document provides the detailed description of how a Phase II proposal gets turned into commands executed by the spacecraft and instrument and the timing associated with those. The TRANS Scripting Guide is probably the most impenetrable and incomprehensible document issued by STScI, and ARs should avoid it.

A User's Guide to the GHRIS Software

Version 1.0 of this document, written by R.D. Robinson, is dated November, 1990. Version 2.1 was issued in June, 1993, by J. Blackwell et al. Both documents describe the software written under the auspices of the GHRIS Investigation Definition Team (IDT) at Goddard Space Flight Center. This software is for the reduction and analysis of GHRIS data, and reproduces, in IDL, the software provided by STScI within the **iraf/stsdas** environment.

4. Document Disposition and Archiving

Many of the documents just described are available only as paper. We anticipate that no ARs will need to refer to them, but in case that need should arise copies have been provided to the library at STScI. In addition, key individuals associated with the GHRIS may have personal copies.

5. A GHRIS Bibliography

Starting with version 4 of the GHRIS Instrument Handbook, we provided a listing of papers published that were based on data from the GHRIS, with an additional few that may have information of particular use to GHRIS researchers. The most recent of those lists was updated in May, 1995, when version 6 of the IH appeared. We provide here a complete listing as of September, 1997. As before, only papers in refereed journals are shown, except for a few specific symposia that featured GHRIS results.

Ultraviolet Reddening and Extinction

“Ultraviolet Photometry from the Orbiting Astronomical Observatory. II. Interstellar Extinction.”

Bless, R.C., and Savage, B.D. 1972, ApJ, 171, 293–308.

“Studies of Ultraviolet Interstellar Extinction with the Sky-survey Telescope of the TD-1 Satellite.”

Nandy, K., Thompson, G.I., Jamar, C., Monfils, A., and Wilson, R. 1976, A&A, 51, 63–69.

“Empirical Effective Temperatures and Bolometric Corrections for Early-Type Stars.”

Code, A.D., Davis, J., Bless, R.C., and Hanbury Brown, R. 1976, ApJ, 203, 417–434.

“Interstellar Extinction in the UV”

Seaton, M.J. 1979, MNRAS, 187, 73P–76P.

“Observed Properties of Interstellar Dust”

Savage, B.D., and Mathis, J.S. 1979, ARA&A, 17, 73–112.

GHRIS-Related Technical Papers

“Ultraviolet High-Resolution Spectroscopy from the Space Telescope.”

Ebbets, D.C., Brandt, J.C., and the HRS Investigation Definition Team 1983, *PASP*, 95, 543–549.

“Wavelengths and Intensities of a Platinum/Neon Hollow Cathode Lamp in the Region 1100–4000 Å”

Reader, J., Acquista, N., Sansonetti, C.J., and Sansonetti, J.E. 1990, *ApJS*, 72, 831–866.

“Status of the Goddard High Resolution Spectrograph in May 1991.”

Ebbets, D.C., Brandt, J., Heap, S. 1991, in *The First Year of HST Observations*, edited by A.L. Kinney and J.C. Blades, p. 110-122,

“Scattered Light in the Echelle Modes of the Goddard High Resolution Spectrograph Aboard the Hubble Space Telescope. I. Analysis of Prelaunch Calibration Data.”

Cardelli, J.A., Ebbets, D.C., and Savage, B.D. 1990, *ApJ*, 365, 789–802.

“Scattered Light in the Echelle Modes of the Goddard High Resolution Spectrograph Aboard the Hubble Space Telescope. II. Analysis of Inflight Spectroscopic Observations.”

Cardelli, J.A., Ebbets, D.C., and Savage, B.D. 1993, *ApJ*, 413, 401–415.

“Resolution and Noise Properties of the Goddard High Resolution Spectrograph”

Gilliland, R.L., Morris, S.L., Weymann, R.J., Ebbets, D.C., and Lindler, D.J. 1992, *PASP*, 104, 367–382.

This last paper is especially recommended for its discussion of the deconvolution of the effects of the Point Spread Function (PSF) and Line Spread Function (LSF) of *HST* and the GHRIS.

“Final Report of the Science Verification Program for the Goddard High Resolution Spectrograph for the Hubble Space Telescope”

Ebbets, D.C. 1992, prepared for NASA/Goddard Space Flight Center by Ball Aerospace Systems Group.

This is a technical document prepared by Ball to fulfill a contractual requirement. It provides a detailed description of the tests and calibrations performed during the Science Verification phase that occurred immediately after the launch of *HST*. We cite it here for completeness, but a General Observer should usually be able to get the information that he or she needs from this *Handbook* or by consulting us.

“The Goddard High Resolution Spectrograph: Instrument, Goals, and Science Results”

Brandt, J.C., et al. 1994, *PASP*, 106, 890–908.

“Calibrating Hubble Space Telescope: Proceedings of a Workshop Held at STScI”

Blades, J.C., and Osmer, S.J., editors, published by STScI.

This contains several papers of relevance for data analysis.

“Calibration Product Review for the GHRIS in Early Cycle 4”

Hulbert, S.J., Sherbert, L.E., Soderblom, D.R., and Leitherer, C.L., 1994, GHRIS Instrument Science Report No. 67.

This Report summarizes the status of calibrations and calibration reference files for the GHRIS. Each calibration file that is referred to in data headers is briefly described as well.

“The Goddard High Resolution Spectrograph: In-Orbit Performance”

Heap, S.R., et al. 1995, PASP, 107, 871.

“Tomography/Power Spectrum Techniques for Removal of Fixed Pattern Noise from Hubble Space Telescope Spectra”

Lyu, C.-H., Bruhweiler, F.C., and Smith, A.M. 1995, ApJ, 447, 880–888.

GHRIS Scientific Papers

A number of GHRIS-related papers are concentrated in some special volumes whose contents will not be itemized here:

- *The First Year of HST Observations*, 1991, edited by A.L. Kinney and J.C. Blades, and published by STScI.
- *Astrophysical Journal Letters*, volume 377, number 1, 1991.
- *Science with the Hubble Space Telescope*, 1992, edited by P. Benvenuti and E. Schreier, and published by ESO.
- *Astrophysical Journal Letters*, volume 435, number 1, 1994.
- *Science with the Hubble Space Telescope II*, 1995, edited by P. Benvenuti, F.D. Macchetto, and E.J. Schreier, and published by STScI.
- GHRIS Science Symposium

1992:

“The Abundance of Boron in Three Halo Stars”

Duncan, D.K., Lambert, D.L., and Lemke, M. 1992, ApJ, 401, 584–595.

“Ultraviolet Observations of the Gas Phase Abundances in the Diffuse Clouds Toward Zeta Ophiuchi at 3.5 Kilometers per Second Resolution”

Savage, B.D., Cardelli, J.A., and Sofia, U.J. 1992, ApJ, 401, 706–723.

“Fractionation of CO in the Diffuse Clouds Toward Zeta Ophiuchi”

Sheffer, Y., Federman, S.R., Lambert, D.L., and Cardelli, J.A. 1992, ApJ, 397, 482–491.

“Highly Ionized Atoms Toward HD 93521.”

Spitzer, L., and Fitzpatrick, E.L. 1992, ApJ, 391, L41–L44.

“Ultraviolet and Optical Spectral Morphology of Melnick 42 and Radcliffe 136a in 30 Doradus”

Walborn, N.R., Ebbets, D.C., Parker, J.W., Nichols-Bohlin, J., and White, R.L. 1992, ApJ, 393, L13–L16.

“Detection of a Proton Beam During the Impulsive Phase of a Stellar Flare”

Woodgate, B.E., Robinson, R.D., Carpenter, K.G., Maran, S.P., and Shore, S.N. 1992, ApJ, 397, L95–L98.

1993:

“Interstellar Mg II and C IV Absorption Toward Mrk 205 by NGC 4319: An ‘Optically-Thick’ QSO Absorption System”

Bowen D.V., and Blades, J.C. ApJ, 403, L55–L58.

“Observations of 3C 273 with the Goddard High Resolution Spectrograph on the Hubble Space Telescope”

Brandt, J.C., et al. 1993, AJ, 105, 831–846.

“The Galactic Halo and Local Intergalactic Medium toward PKS 2155–304”

Bruweiler, F.C., Boggess, A., Norman, D.J., Grady, C.A., Urry, C.M., and Kondo, Y. 1993, ApJ, 409, 199–204.

“Ultraviolet Transitions of Low Condensation Temperature Heavy Elements and New Data for Interstellar Arsenic, Selenium, Tellurium, and Lead”

Cardelli, J.A., Federman, S.R., Lambert, D., and Theodosiou, C.E. 1993, ApJ, 416, L41–L44.

“Abundance of Interstellar Carbon Toward Zeta Ophiuchi”

Cardelli, J.A., Mathis, J.S., Ebbets, D.C., and Savage, B.D. 1993, ApJ, 403, L17–L20.

“Detection of Boron, Cobalt, and other Weak Interstellar Lines toward ζ Ophiuchi”

Federman, S.R., Sheffer, Lambert, D.L., and Gilliland, R.L. 1993, ApJ, 413, L51–L54.

“Quantitative Spectroscopy of K647 — the PNN of Ps1 in the Globular Cluster M15”

Heber, U., Dreizler, S., and Werner, K. 1993, Acta Astron., 43, 337–342.

“The Interstellar Abundances of Tin and Four Other Heavy Elements”

Hobbs, L.M., Welty, D.E., Morton, D.C., Spitzer, L., and York, D.G. 1993, ApJ, 411, 750–755.

“Time-Series Observations of O Stars. III. IUE and HST Spectroscopy of ζ Ophiuchi and Implications for the ‘Photospheric Connection’”

Howarth, I.D. et al., 1993, ApJ, 417, 338–346.

“Hubble Space Telescope Spectra of the Phase-Modulated Wind in the SMC O+WR Binary R31”

Hutchings, J.B., Morris, S.C., and Bianchi, L. 1993, ApJ, 410, 803–807.

“Deceleration of Interstellar Hydrogen at the Heliospheric Interface”

Lallement, R., Bertaux, J.-L., and Clarke, J.T. 1993, Science, 260, 1095–1098.

Provides a good illustration of geocoronal Ly- α with the LSA and Echelle-A.

“High Resolution UV Stellar Spectroscopy with the HST/GHRS, Challenges and Opportunities for Atomic Physics”

Leckrone, D.S., Johansson, S., Wahlgren, G.M., and Adelman, S.J. 1993, Physica Scripta, T47, 149–156.

“Goddard High Resolution Spectrograph Observations of the Local Interstellar Medium and the Deuterium/Hydrogen Ratio Along the Line of Sight Toward Capella”

Linsky, J.L., Brown, A., Gayley, K., Diplas, A., Savage, B.D., Ayres, T.R., Landsman, W., Shore, S.N., and Heap, S.R. 1993, ApJ, 402, 694–709.

“The Boron Abundance of Procyon”

Lemke, M., Lambert, D.L., and Edvardsson, B. 1993, PASP, 105, 468–475.

“Detection of [O II] λ 2471 from the Io Plasma Torus”

McGrath, M.A., Feldman, P.D., Strobel, D.F., Moos, H.W., and Ballester, G.E. 1993, ApJ, 415, L55–L58.

“A Search for Proton Beams During Flares on AU Microscopii”

Robinson, R.D., Carpenter, K.G., Woodgate, B.E., and Maran, S.P. 1993, ApJ, 414, 872–876.

“Observations of the Gaseous Galactic Halo Toward 3C273 with the Goddard High Resolution Spectrograph”

Savage, B.D., Lu, L., Weymann, R.J., and Morris, S.L. 1993, ApJ, 404, 124–143.

“Goddard High Resolution Spectrograph Observations of Narrow Discrete Stellar Wind Absorption Features in the Ultraviolet Spectrum of the O7.5III Star ζ Persei”

Shore, S.N., Altner, B., Bolton, C.T., Cardelli, J.A., and Ebbets, D.C. 1993, ApJ, 411, 864–868.

“The Early Ultraviolet Spectral Evolution of Nova Cygni 1992”

Shore, S.N., Sonneborn, G., Starrfield, S., Gonzalez-Riestra, R., and Ake, T.B. 1993, AJ, 106, 2408–2428.

“High-Resolution Ultraviolet Observations of the Interstellar Diffuse Clouds toward μ Columbae”

Sofia, U.J., Savage, B.D., and Cardelli, J.A. 1993, ApJ, 413, 251–267.

“Composition of Interstellar Clouds in the Disk and Halo. I. HD 93521”

Spitzer, L., and Fitzpatrick, E.L. 1993, ApJ, 409, 299–318.

1994:

“Evidence for a Disk in the Wind of HD 93521: UV Line Profiles from an Axisymmetric Model”

Bjorkman, J.E., Ignace, R., Tripp, T.M., and Cassenelli, J.P. 1994, ApJ, 435, 416–434.

“Interstellar and Intergalactic Magnesium and Sodium Absorption toward SN 1993J”

Bowen, D.V., Roth, K.C., Blades, J.C., and Meyer, D.M. 1994, ApJ, 420, L71–L74.

“The Abundance of Heavy Elements in Interstellar Gas”

Cardelli, J.A. 1994, Science, 265, 209–213.

“Interstellar Detection of the Intersystem Line Si II] λ 2335 toward ζ Ophiuchi”

Cardelli, J.A., Sofia, U.J., Savage, B.D., Keenan, F.P., and Dufton, P.L. 1994, ApJ, 420, L29–L32.

“GHRS Observations of Cool, Low-Gravity Stars. I. The Far-Ultraviolet Spectrum of α Orionis (M2Iab)”

Carpenter, K.G., Robinson, R.D., Wahlgren, G.M., Linsky, J.L., and Brown, A. 1994, ApJ, 428, 329–344.

“Hubble Space Telescope Goddard High Resolution Spectrograph H₂ Rotational Spectra of Jupiter’s Aurora”

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