NIEDERSÄCHSISCHE STAATS- UND
UNIVERSITÄTSBIBLIOTHEK GÖTTINGEN

Werk

Jahr: 1974
Kollektion: fid.geo
Signatur: 8 Z NAT 2148:40
Digitalisiert: Niedersächsische Staats- und Universitätsbibliothek Göttingen
Werk Id: PPN1015067948_0040
PURL: http://resolver.sub.uni-goettingen.de/purl?PPN1015067948_0040

LOG Id: LOG_0091
LOG Titel: The AEROS-EUV Spectrometer
LOG Typ: article

Übergeordnetes Werk

Werk Id: PPN1015067948
PURL: http://resolver.sub.uni-goettingen.de/purl?PPN1015067948

Terms and Conditions

The Goettingen State and University Library provides access to digitized documents strictly for noncommercial educational, research and private purposes and makes no warranty with regard to their use for other purposes. Some of our collections are protected by copyright. Publication and/or broadcast in any form (including electronic) requires prior written permission from the Goettingen State- and University Library.
Each copy of any part of this document must contain there Terms and Conditions. With the usage of the library's online system to access or download a digitized document you accept the Terms and Conditions.
Reproductions of material on the web site may not be made for or donated to other repositories, nor may be further reproduced without written permission from the Goettingen State- and University Library.

For reproduction requests and permissions, please contact us. If citing materials, please give proper attribution of the source.

Contact

Niedersächsische Staats- und Universitätsbibliothek Göttingen
Georg-August-Universität Göttingen
Platz der Göttinger Sieben 1
37073 Göttingen
Germany
Email: gdz@sub.uni-goettingen.de

J. Geophys. 40, 577—584, 1974

The AEROS-EUV Spectrometer

G. Schmidtke, W. Schweizer, and M. Knothe

Institut für Physikalische Weltraumforschung, Freiburg i. Br.

Received April 1, 1974

Abstract. During the mission of the satellite AEROS-A the EUV spectrometer monitored the solar photon fluxes within the wavelength range from 106—16 nm. In a special mode of operation the attenuation of specific emission lines within the upper atmosphere has been measured to derive neutral densities by means of EUV absorption analysis. Also airglow emissions and degradation effects of the multipliers have been recorded by the two channel instrument of planar grating geometry, which is described in detail.

Key words: Aeronomy — Solar EUV Photon Fluxes — Upper Atmosphere — Absorption Analysis — Neutral Densities — Airglow — Planar Grating Geometry.

1. Scientific Aims

The AEROS-EUV spectrometer has been developed specificly with regard to the scientific objectives of the German—US aeronomy satellite AEROS. To the integrated data evaluation of this program the EUV spectrometer contributes the solar extreme ultraviolet (EUV) emission flux densities within the wavelength range from 106 nm to 16 nm.

This energy interval constitutes the main portion in the energy balance of the upper atmosphere due to the absorption of the radiation by atomic and molecular oxygen and molecular nitrogen above 120 km resulting into the production of ion-electron pairs and the excitation of neutral particles (e.g. fluorescent scattering). The generated photoelectrons heat up the electron gas, the ions, and finally the neutral particles, whereas the excited neutrals do reemit most of the absorbed photon energy at longer wavelengths at least for heights where the collision probability is negligible during the absorption-reemission process.

The conversion of the EUV energy within the upper atmosphere will be investigated computing the primary and secondary ionelectron production rates, the energy spectrum of the photoelectrons, and the excitation of neutral components (Fig. 1). These data are needed for the integrated data evaluation to calculate the thermalization of the photo-electrons and their role in the transfer of EUV energy.

For special parts of the orbit the number densities of atomic oxygen and molecular nitrogen will be derived from attenuation measurements of

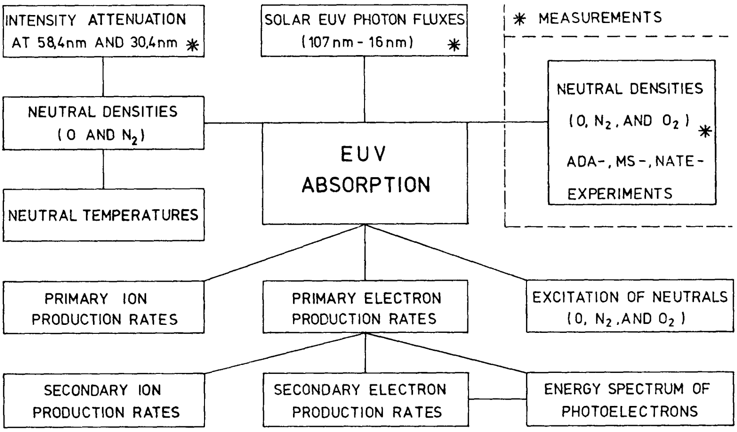

Fig. 1. Data evaluation of the AEROS-EUV spectrometer

the two helium emission resonance lines at 58.4 nm and 30.4 nm. These data will contribute to the construction of atmospheric models and to the calibration of the mass spectrometers on board of the satellite.

2. *Measuring Principle*

The spectrometer makes use of non-focusing planar grating geometry, which has been applied in space research first by Bedo and Hinteregger (1965).

The ambient ionospheric plasma has to be screened off from the optical part of the spectrometer by a set of three metallic double grids (Fig. 2). The outer one is at satellite zero potential, the middle one at +28 V, and the inner one at —22 V. The optical transparency exceeds 90%.

The radiation to be analyzed passes through these metallic grids, through which the spectrometer is outgassed at the same time.

An aperture mounted in front of the grating limits the accepted radiation and also protects the inner volume from straylight.

The solar radiation passing the aperture is diffracted by the planar grating. According to the theory a specific wavelength l will be diffracted at the angle b depending on the angle a of the incident radiation and the grating constant d,

$$l = d(\sin a - \sin b)\,. \tag{1}$$

Spectral selection is achieved by a revolving Soller collimator of the grid type, which is dimensioned to act as a mechanical collimator and as a diffraction filter at the same time (Schmidtke, 1968; Schmidtke, 1970).

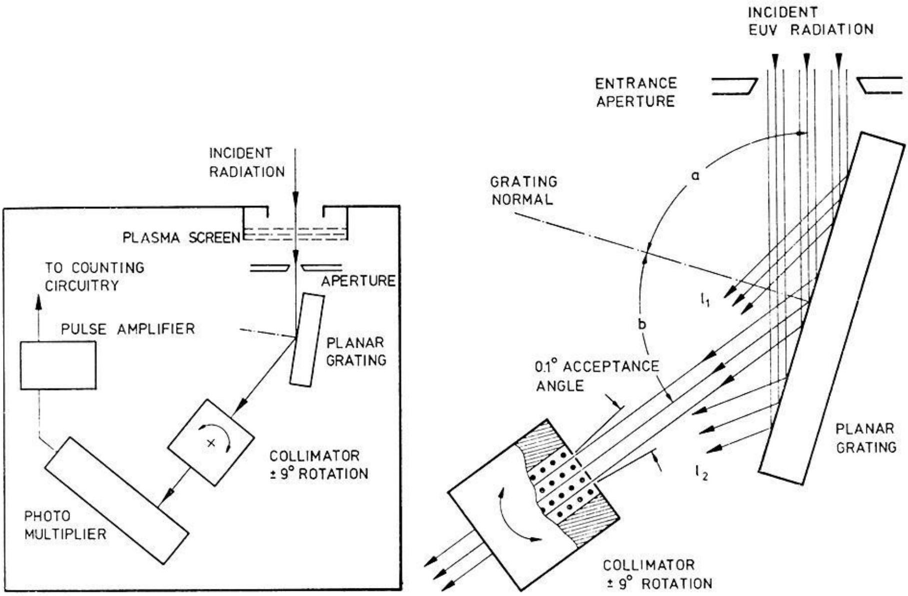

Fig. 2. a Schematic illustration of the EUV spectrometer, b Layout of optical components

The function of the diffraction filter is to lower the amount of scattered light, especially of hydrogen-Lyman-alpha.

The photon intensity is measured by a magneto-electrostatic multiplier (Bendix MEM 306) with a tungsten photocathode, followed by an amplifier and pulse counting electronics.

3. *Experimental Technique*

Two similar optical systems are incorporated in the EUV spectrometer, each consisting of an aperture with a plasma screen, a planar grating (2100 grooves mm^{-1} in channel 1 and 3600 grooves mm^{-1} in channel 2), a Soller collimator, a photomultiplier with high voltage supply, and an amplifier. The two spectrometers are mounted in one box fabricated of magnesium and sealed from the spacecraft interior volume, with the optical planes being oriented in parallel.

Both collimators can rotate about their common axis within an angular range of 18°. Their alignments with respect to the grating (angles *b*) differ by 2°, so that the solar emissions at 58.4 nm (channel 1) and at 30.4 nm (channel 2) are recorded simultaneously.

In channel 1 the angle *b* varies from 50° to 68° and in channel 2 from 52° to 70°, providing the wavelength ranges from 106 nm to 31 nm and from 57 nm to 16 nm, respectively, with an angle *a* of 84.5 °. The spectral region from 52 nm to 32 nm is covered in both spectrometers.

Taking into account the geometrical window function of the collimators a spectral resolution of 0.5 nm to 0.4 nm and 0.3 nm to 0.2 nm, respectively, is derived, however, the diffraction within the collimator will increase these values almost a factor of two for the longer wavelengths.

The design of the collimator makes use of a new technique: While usually electrolytically formed grids are utilized, here frames strung with fine parallel wires (stainless steel, 0.028 mm diameter) provide the slit structures. Characteristic distances of the frames determine the optical ray path. Within a carefully fabricated block 5 frames of different thicknesses are aligned with an accuracy better than 0.001 mm.

The total geometrical aperture (full width) is about 0.1°.

The collimator is rotated in 492 discrete steps driven by a stepping motor with gear train, which is lubricated with UHV lubricant. This part is sealed against the optical part of the spectrometer.

In order to save energy the motor is powered (2.4 W) during step switching only, resulting in an average power consumption of approximately 0.45 W.

The anodes of the multipliers are connected to charge sensitive preamplifiers followed by voltage amplifiers, dc restorers, and discriminators. The sensitivity can be varied in 10 steps from 8.10^{-15} C to 5.10^{-13} C. Two of these steps (2.10^{-14} C and 2.10^{-13} C) are switchable by telecommand. The 10 steps are needed to measure degradation effects of the multipliers during calibration and during flight (see 4.3).

4. *Modes of Operation*

The AEROS satellite is of a Scout type, therefore solar pointing of the spin axis is possible with an accuracy of some tenths of a degree only. Misalignments up to 5° have to be taken into consideration. The resulting wavelength shift due to inaccurate solar pointing and the spin rotation has been investigated by Schmidtke *et al.* (1973). As a result two modes have been introduced for the measurement of the photon fluxes within the spectral region of interest.

4.1. Continuous Mode (I)

If the spin axis of the satellite is pointed at the center of the solar disc within a cone of 1.5° half angle of opening 492 steps are scanned at 2 Hz. After each complete scan the stepper motor repositions the collimators within 18 sec.

A typical spectrum in this measuring mode as obtained during AEROS mission is shown in Fig. 3. It has not been corrected, yet. A computer program is being prepared for elimination of the influence of the spin and the mispointing of the satellite.

4.2. Discontinuous Mode (II)

For solar mispointing exceeding 1.5° the sampling frequency is 4 Hz during 2 sec of optimum measuring conditions every 6 sec spin period (Schmidtke *et al.*, 1973). Data will be stored temporarily in order to feed them to the telemetry in the same sequence as in mode I. Then the collimators stay in fixed positions during 4 sec. No counts will be recorded during this period.

4.3. Calibration Mode (III)

a) In the shadow phase of the orbit one spectral scan in mode I measures background radiation (including cosmic and hydrogen-Lyman-alpha background and possibly airglow emission e.g. from auroral events).

b) For calibration purposes the multiplier photocathodes are exposed to a nickel 63 radioactive beta source and the count rates recorded at the 10 levels of the preamplifier-sensitivity during 6 sec each. A typical curve is shown in Fig. 4.

c) Another scan provides data due to cosmic background and airglow emissions at a later time.

4.4. Absorption Mode (IV)

The collimators will be set at step number 210, at which position the helium emissions at 58.4 nm and 30.4 nm are measured during 246 sec. Operation in mode IV will start automatically if the EUV spectrometer is turned on at sunrise conditions, which is the usual measuring program.

4.5. Absorption Mode by Telecommand (V)

At special occasions (e.g. at low perigees in the sun phase or for optimal conditions for absorption analysis at satellite sunset) the mode IV can be selected by telecommand. It will then continue until the end of the measuring orbit.

Meanwhile many density profiles of atomic oxygen have been derived from these measurements (Schmidtke *et al.*, 1974).

5. Calibration

The complicated calibration procedures and results will be presented in detail elsewhere.

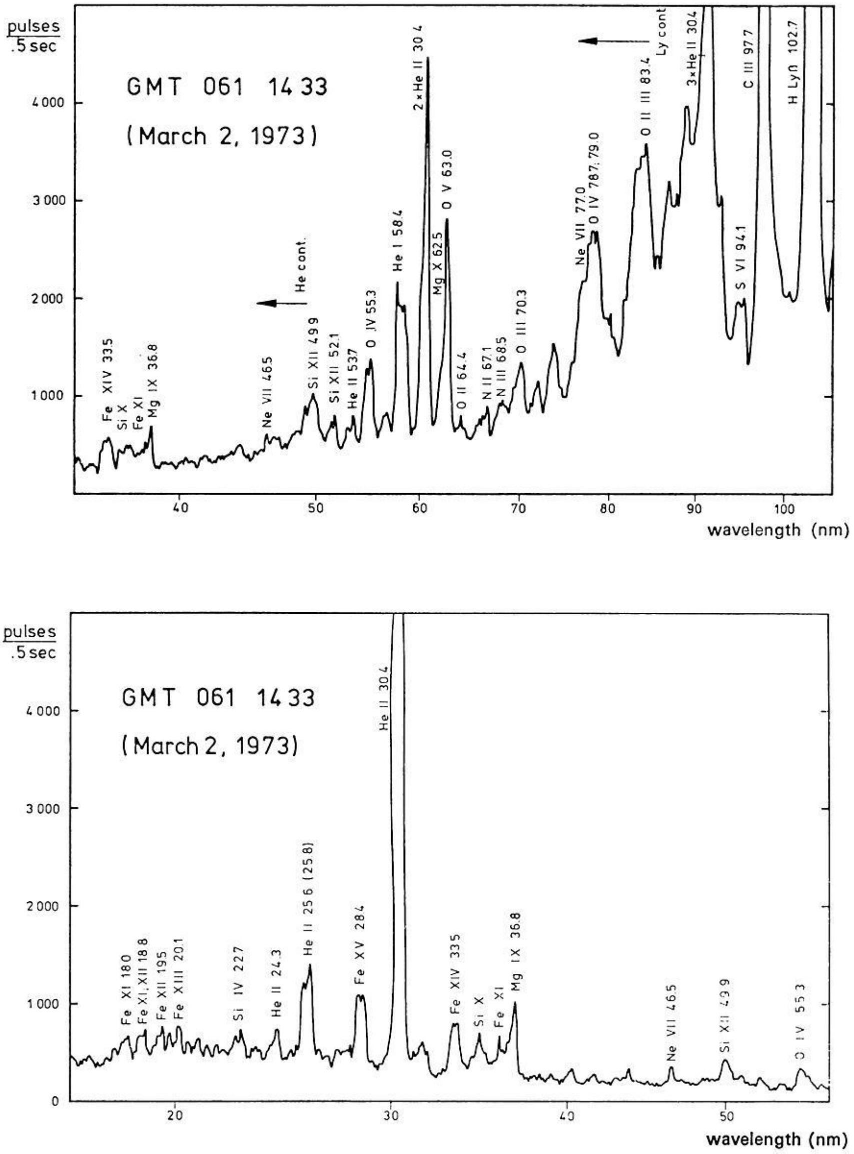

Fig. 3. Solar spectrum. a channel 1. b channel 2

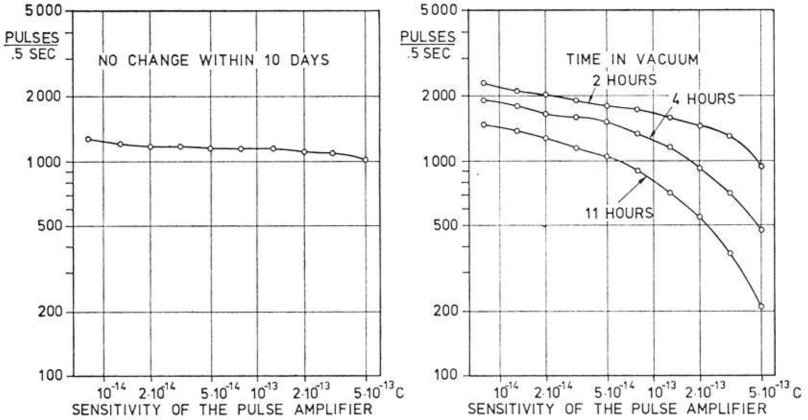

Fig. 4. Countrates at different sensitivities of the amplifier. a for a multiplier selected for flight. b for a multiplier showing degradation

To perform the calibration of the EUV spectrometer with an accuracy as required for the integrated data evaluation different methods have been applied. The measurement of the calibration parameters includes the spatial non-uniformities of the grating and of the photocathode of the multiplier, as a function of wavelength, angle of the incident radiation, and time. To determine the efficiency of the instrument a combination of results of the following measurements is being applied.

5.1. Preflight calibration with radiation emitted by the electron synchrotron at the Physikalisches Institut der Universität in Bonn, with variation of the angles of incidence and the synchrotron energies between 0.75 and 1.5 GeV. Polarization effects are measured, too.

Measurement of line emissions as generated in gaseous discharges applying Geiger counter techniques, tungsten photodiodes, and a NBS calibrated detector.

5.2. In-flight calibration in mode IIIb measures the degradation of the multipliers. Longtime multiplier efficiency tests in the laboratory are conducted to answer the question whether the response to the nickel 63 radioactive source is representative for the response to helium 30.4 nm radiation and the 0.2 nm emission from iron 55.

5.3. As the variation of a number of solar emission lines has been found to be relatively small, these lines will be used for cross-checks.

5.4. The overlapping range from 57 nm to 32 nm of channels 1 and 2 also allows cross-checks.

5.5. Cross calibration with other instrumentation flown in the Apollo Telescope Mount or in the AE-C, AE-D series (Hinteregger *et al.*, 1973; Heath and Osantowski, 1973), is intended.

Acknowledgements. We would like to express our warmest thanks to Drs. Hinteregger, Bedo, Hall, and Manson of AFCRL, Bedford, for their help in getting this experiment started.

We also thank R. Hartig, G. Neumann, Dr. Siemann, and co-workers of Dornier-System for the excellent design and fabrication of the spectrometer.

The excellent management and administration of grants WRK 99, 192, and 226 by Dr. Lübbert of the Bundesministerium für Forschung und Technologie and R.-D. Günther and W. Wiche of the Gesellschaft für Weltraumforschung is gratefully acknowledged.

References

Bedo, D. E., Hinteregger, H. E.: Collimating grating monochromators for the vacuum ultraviolet. Japan. J. Appl. Phys. *4*, 473—479, 1965

Heath, D. F., Osantowski, J. F.: An extreme UV photometer for solar observations from Atmospheric Explorer. Radio Sci. *8*, 361—366, 1973

Hinteregger, H. E., Bedo, D. E., Manson, J. E.: The EUV spectrophotometer on Atmospheric Explorer. Radio Sci. *8*, 349—356, 1973

Schmidtke, G.: Soller-Blendensysteme als Kollimatoren und Beugungsfilter. Z. Angew. Phys. *25*, 314—318. 1968

Schmidtke, G.: Diffraction filters in XUV spectroscopy. Appl. Optics *9*, 447—450, 1970

Schmidtke, G., Schmidt, K., Rebstock, C.: Modellrechnungen und -messungen zum AEROS-EUV-Spectrometer, BMFT-FB W 73—20, 1973

Schmidtke, G., Rawer, K., Fischer, Th., Lotze, W.: Atomic oxygen profiles determined by EUV absorption analysis. Space Res. *XIV*, 169—172, 1974

G. Schmidtke
W. Schweizer
M. Knothe
Institut für Physikalische
Weltraumforschung
D-7800 Freiburg i. Br.
Heidenhofstr. 8
Federal Republic of Germany