J. Geophys. 41, 215–218, 1975

Short Communications

Measured and Calculated Secondary Electron Energy Spectra (20 - 1500 eV) above 120 km

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Received September 10, 1974

Key words: Photoelectrons – Energy Spectra – Rocket Measurements – Monte Carlo Simulation.

In February and May 1973 three sounding rockets were launched in the scope of the "AEROS-Support-Rocket-Program" which carried a combined payload of 5 (in one case 6) experiments to record vertical profiles of aeronomical parameters. Besides neutral and ion composition, electron density, airglow and thermal electron flux, the energy spectrum of electrons in the range of 20 to 1500 eV was measured by a cylindrical plate analyzer device developed by the authors. Whilst an integrated data evaluation of all the experiments of these flights will be presented in a future paper, a special aspect of the electron energy spectra measurements – the comparison with Monte-Carlo calculations – should be reported here.

The data presented here were measured during two of the three flights, from one flight the data could not be evaluated because of a defect in the payload-system. Some characteristics of the successful flights are summarized in Table 1.

The cylindrical plate analyzer as an energy filter is widely used to measure energy spectra of charged particles and should not be described here in detail therefore (c. f. Hughes and Rojansky, 1929). In the range from 20 to 1500 eV the electron flux

Table 1. Data of the rocket flights

Flight	NATAL	ANDOYA I
Range Place	Natal (Brazil)	Andoya (Norway)
Latitude	5° 55′ 19″ S	69° 17′ 33″ N
Rocket Name	Black Brant Vc	Black Brant Vc
Apogee	308 km	306 km
Date	Feb. 1, 1973	May 12, 1973
Time	14.33 LT	13.42 LT
Solar zenith angle	39°	52.8°
Solar activity (F 10.7)	91	85
Magnetic activity Kp	3^+	2
local (ΔB_Z)	—	$< 20\,\gamma$

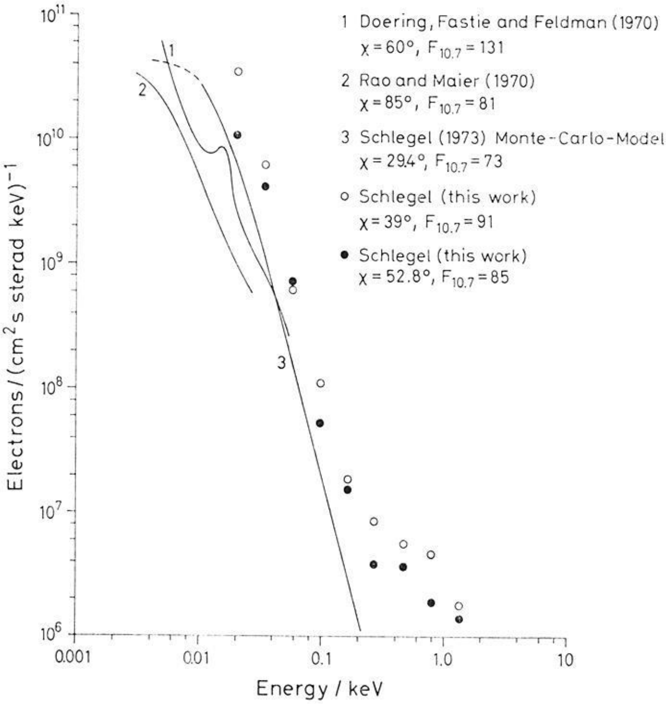

Fig. 1. Comparison of electron energy spectra measured and calculated by these authors and results of other authors.
○ flight NATAL, 306 km altitude
● flight ANDOYA I, 298 km altitude

was recorded in 9 logarithmicaly spaced energy channels with a width of $\frac{\Delta E}{E} = \pm 6\%$. The electrons having passed the analyzer were detected with a continuous channel electron multiplier (channeltron). Details of the experiment are described in an internal report (Loidl and Schlegel, 1972). The experiment was looking perpendicular to the rocket spin axis and the sample time of one energy interval was matched to the spin frequency of the rocket providing an integration over an azimuth angle of 2π. It took 2.56 s to record one energy spectrum consisting of 9 counting rates of 9 energy channels and a reference value.

Typical energy spectra for the flights ANDOYA I and NATAL are shown in Fig. 1 (full and open dots). The shapes of the spectra were remarkably constant over the hight range from about 180 km to the apogee and the counting rates exhibit few scatter in the energy range from 20 to about 400 eV. The slope of the energy spectra in this range in a double logarithmical scale was $-(3.78 \pm 0.08)$ for the flight NATAL and $-(3.0 \pm 0.1)$ for the flight ANDOYA I. Below 180 km the slopes decreased in both cases. At 130 km (the minimum measuring altitude) it was approximately -2.4 for the flight NATAL and approximately -1.9 for the flight ANDOYA I.

The different slopes of the energy spectra for the two flights are probably a consequence of the different solar zenith angles at the flight time (c.f. Table 1). That means the electrons of this energy range are mainly photoelectrons or secondaries produced by photoelectrons. For comparison the photoelectron spectra measured by other authors (Doering, Fastie and Feldman, 1970; Rao and Maier, 1970) are plottet in Fig. 1. The agreement is reasonably good taking into account the different solar activities (characterized by $F_{10\cdot 7}$) and solar zenith angles. Recent measurements of photoelectron energy spectra are also in the same order of magnitude (Hays and Sharp, 1973; Mukai and Hirao, 1973).

The solid curve in Fig. 1 represents a special result of a Monte-Carlo simulation of a model ionosphere (Schlegel, 1974). Since this Monte-Carlo model is described elsewhere in detail (Schlegel, 1971; Schlegel, 1973) only its input parameters should be mentioned here again. Besides solar activity and the solar zenith angle these are density profiles of O, O_2, N_2, the electron density profile, the solar UV and EUV spectrum, the earth magnetic field and several reaction rate cross sections. Comparing the calculated curve with our measured values yields that the slope of the Monte-Carlo curve (-3.7) is in very good accordance with the slope of the measured energy spectra, but the absolute values are too low by a factor of 5. Since the solar activity and the solar zenith angle are not too much different in the case of the Monte-Carlo simulation and at the time of the rocket flights, the factor 5 hardly could be a sole consequence of this small difference. That means that either the input parameters of the Monte-Carlo model are too far away from the real atmospheric conditions during the rocket flights or that the absolute values of the measured energy spectra are too high. Probably both is true. On the one hand the exact calibration of an electron energy analyzer in this energy range is very difficult and thus the absolute values of the electron flux may be wrong by a factor of 2. On the other hand the fact that the input parameter of the model do not fit the atmospheric conditions at the flight time could led to considerable errors in the calculated energy spectra. Specially the density profiles of O, O_2 and N_2 and the solar UV und EUV spectrum have a great influence on the photoelectron spectrum. The model itself could not be too far from reality because of the reliable results with respect to other ionospheric parameters (Schlegel, 1971; Schlegel, 1973). Possibly the integrated data evaluation of all experiments of the flights could provide some data to improve the input parameter set of the model.

Acknowledgements. The authors thank Mr. Kellner for his assistance in building the equipment. The paper is published by permission of Prof. Dieminger, the director of the Max-Planck-Institut für Aeronomie.

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