Measurement of the Auroral Electric Field (1)

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ロケットによる電場の観測

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要旨: 1973年，S-210 ロケット4機により，オーロラに伴う電場の観測が行われ，良好なデータを得ることができた．現在解析中でここでは，観測方法に関して報告する．

Abstract: Measurement of the auroral electric field was carried out by the use of small rockets, S-210JA-13, 14, 15 and 18, by the 14th Japanese Antarctic Research Expedition Team. Table 1 is the list of the observations.

The record of the observations is now on data processing and the results will be reported in the near future. Hence, here the observation method will be described.

Figure 1 shows the construction of the rocket head with double probe. The probes folded prior to launching is projected from the rocket body after the removal of the head cover at the altitude of about 80 km.

The separation of two spherical probes of diameter 3 cm is 1.114 m.

Two probes rotate along with the rocket body axis by spin motion of period about 1 s and pick up the external electric field as alternating voltage signals synchronized with the spin motion. This is very effective to eliminate disturbances from the records, because most of disturbances are thought to occur with frequencies other than spin frequency.

The principle of measuring the electric field is almost the same as that developed by MOZER and others (1967, 1969). The probe immersed in plasma has the potential lower than the external space potential by the amount of potential drop through the

Table 1. List of observations for auroral electric field.

Rocket	S-210JA-13	S-210JA-14	S-210JA-15	S-210JA-18
Date	1973.06.10	1973.03.25	1973.06.12	1973.08.23
Time (45°EMT)	23:20:18	23:47:05	00:10:56	03:53:30
Height of apogee (km)	123.4	113.9	124.5	129.4
Probe	double	double	double	quadruple

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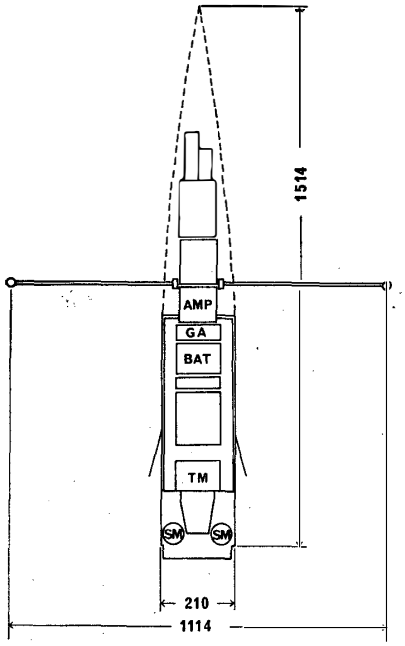

Fig. 1. Double probe experiments on the payload of S-210JA-13, 14, 15. AMP: amplifier, GA: geomagnetic aspect meter, BAT: battery, TM: telemeter, SM: spin motor

ion sheath surrounding it. The potential drop depends upon the conditions of plasma and the drop value is estimated to be the order of 0.1 to 1 V in the ionosphere. This is too large to allow the direct measurement of space potential. The contact potential on the surface of probe also makes the measurement difficult for single probe. By using balanced double probes, most part of these obstructions will be canceled and only the unballanced effect is left as noise. Since the sheath resistance displays the part of internal resistance in generator side in the concept of effective circuit, the output led from the double probe to the measuring circuit is given by

$$V=\frac{V_0+(V_1-V_2)}{1+(R_1+R_2)/R}$$

where $V_{1,2}$ and $R_{1,2}$ are disturbing voltages and sheath resistances at the probes 1 and 2 respectively, R is the input resistance of measuring circuit and V_0 is produced by the external electric field, rocket motion in magnetic field, and probe separation as follows,

$$V_0=(\bar{E}+\bar{v}\times\bar{B})\bar{d}\,.$$

The fractional difference of V_1 and V_2 will be neglected on consideration of the measurement, by reading the component of spin frequency.

Figure 2 is the block diagram of the measuring circuit. To obtain the sheath resistance, estimated to be the order of 10^5 to 10^6 ohms, the input resistance is in selection of 10^8 or 10^6 ohms periodically with time duration of 6 and 2 s respectively by the use of relay 2.

In addition to this, relay 1 varies the state of probes in turn from a normal

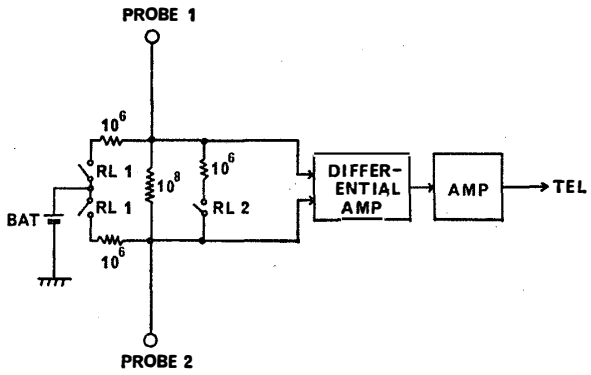

Fig. 2. Block diagram of the electric field meter.

floating mode to a biased mode applied with +1.8 V voltage.

Therefore the following four states appear alternately each with respective durations; floating mode with input resistance 10^8 ohms for 6 s, floating mode with resistance 10^6 ohms for 2 s, biased mode with input resistance 10^8 ohms for 6 s and biased mode with resistance 10^6 ohms for 2 s. The value of sheath resistance involves the information on electron density and temperature, and the analysis of differences between floating and biased modes also gives the estimation of disturbing effects.

Although the double probe gives only one component of electric field normal to the rocket spin axis, the quadruple probe adopted in S-210JA-18 is thought to give three dimensional direction.

As to the term of $\bar{v}\times\bar{B}$, the value will not exceed 50 mV/m because the total magnetic flux at Syowa Station is about $5\times10^4\,\gamma$ and the velocity of rocket is 1 km/s at the largest above the level of 80 km. The value is expected to be the comparable order to the external electric field on the occasion of aurora. Careful comparison with the rocket position and orientation, information obtained simultaneously by a magnetic aspect meter will be indispensable for the true field evaluation.

References

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