Determination of the Sense of Polarization of the Magneto-Ionic z-Component

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Abstract

The sense of polarization of the third magneto-ionic component, the z-component, was determined in a number of cases at the Auroral Observatory at Tromsö during October 1951. The observations showed without exception that the z-component was polarized in the same way as the ordinary component.

1. Introduction

The third magneto-ionic component, the z-component, was first reported by ECKERSLEY (1933). Today the z-component is a well known phenomenon at all stations at high latitudes. Thus at the Norwegian Defence Research Establishment at Kjeller (60° N, 11° E), recordings of both E- and F-layer triple splits are common, and at the Auroral Observatory at Tromsö (70° N, 19° E), the z-component is almost a daily returning phenomenon.

In the last years the magneto-ionic triple splitting has been treated theoretically by a number of writers. The z-wave may be explained as due to a coupling of the usual ordinary mode to the isolated extraordinary mode. The most complete treatment of the problem has perhaps been given by RYDBECK (1951). He shows that for even a smooth ionosphere at moderately high geomagnetic latitudes a z-wave is excited by the vertically incident ordinary wave in the neighbourhood of and at the ordinary reflection level.

According to the theory, the z-component should be polarized in the same way as the ordinary component. HOGARTH (1951), has published a single observation showing that this is the case. The purposes of the present paper is to present additional observations of the effect.

2. Experimental method

Different methods have been used in order to determine the state of polarization of radio waves. In 1932 APPLETON and WATSON-WATT, (WATSON-WATT, 1946) introduced the cathode ray direction-finding technique.

By this technique, the reflected echo is resolved into two components, at right angles, by a crossed loop receiving antenna system. The two components are connected, through identical HF-amplifiers, to the x- and y-plates of a cathode ray tube. If IF-amplification is used, the local oscillator must be common. If an elliptically polarized wave is reflected vertically from the ionosphere, the ellipse of polarization will be directly visible on the screen of the cathode ray oscilloscope.

A detailed study of the state of polarization can only be made if the echos appearing on the screen can be isolated. Appleton and Watson-Watt solved this problem by introducing a circular timebase on the screen with a timebase frequency equal to the pulse repetition frequency of the emitted waves. This solution does not utilize the screen to its full extent and the accuracy is therefore limited. By a time selection technique (gating) it is possible to remedy this difficulty. The cathode ray tube is opened by electronic gate-impulses in

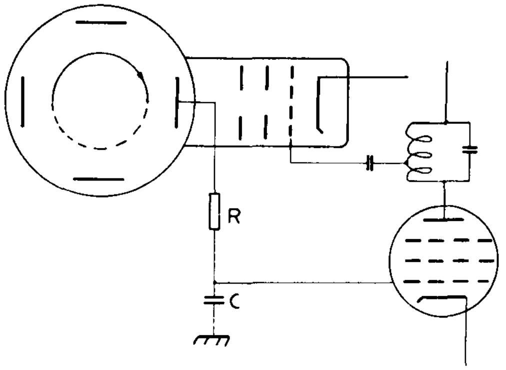

Fig. 1. Determination of the sense of polarization.

synchronism with the wanted signals, otherwise it remains closed.

Appleton and Watson-Watt determined the sense of polarization (sense of rotation of the field vectors) by studying the alterations of the ellipse on the screen when altering the trimming capacity in one of the HF-amplifiers, thus introducing a known phase shift. This method is somewhat difficult since the ellipses undergo constant and rapid fluctuations. In Fig. 1 is illustrated another method by which this difficulty was overcome. As before the x- and y-plates of the cathode ray tube are fed from the two loops respectivily, with conservation of phase relationship. The signal on the x-plates is shifted 90° in phase by the resistor R and the condenser C, and the phase-shifted signal is amplified in the pentode V_1, the anode circuit of which is tuned to the signal frequency. The phase-shifted signal is fed to the grid of the cathode ray tube via a condenser. When the gating signal from the pentode is positive, the brilliancy of the cathoderay tube will increase; when the signal is negative, the brilliancy will decrease. The gating signal goes positive 90° before the signal on the x-plates. This will make visible the upper or the lower part of the ellipse during each cycle according to the sense of rotation of the field vectors. Thus, the sense of polarization can be easily determined, as illustrated in Fig. 1, even if the ellipse of polarization be rapidly varying in size and shape.

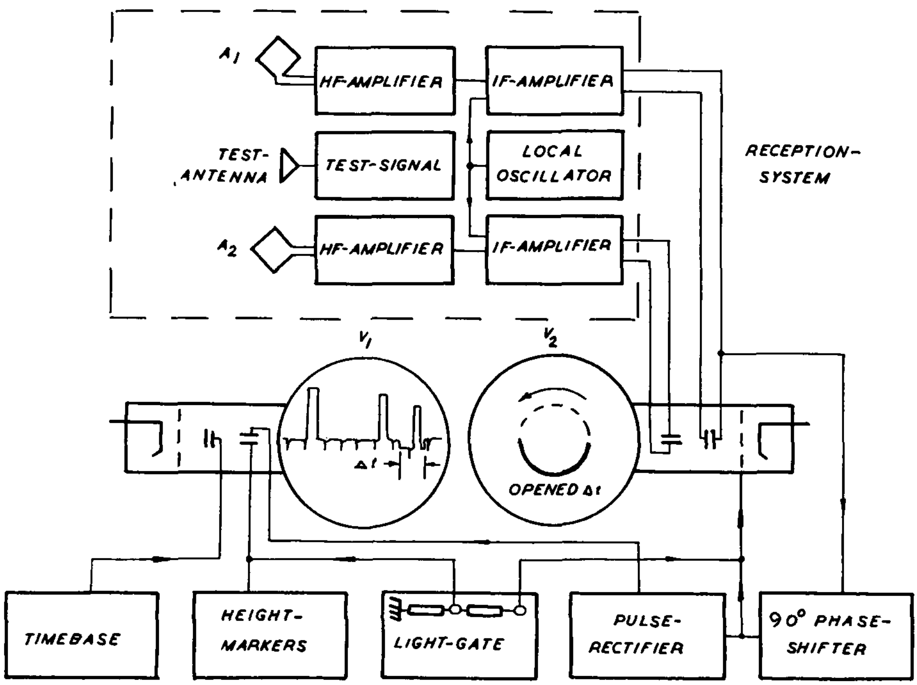

Fig. 2. Block-diagram of the radio polaritmer.

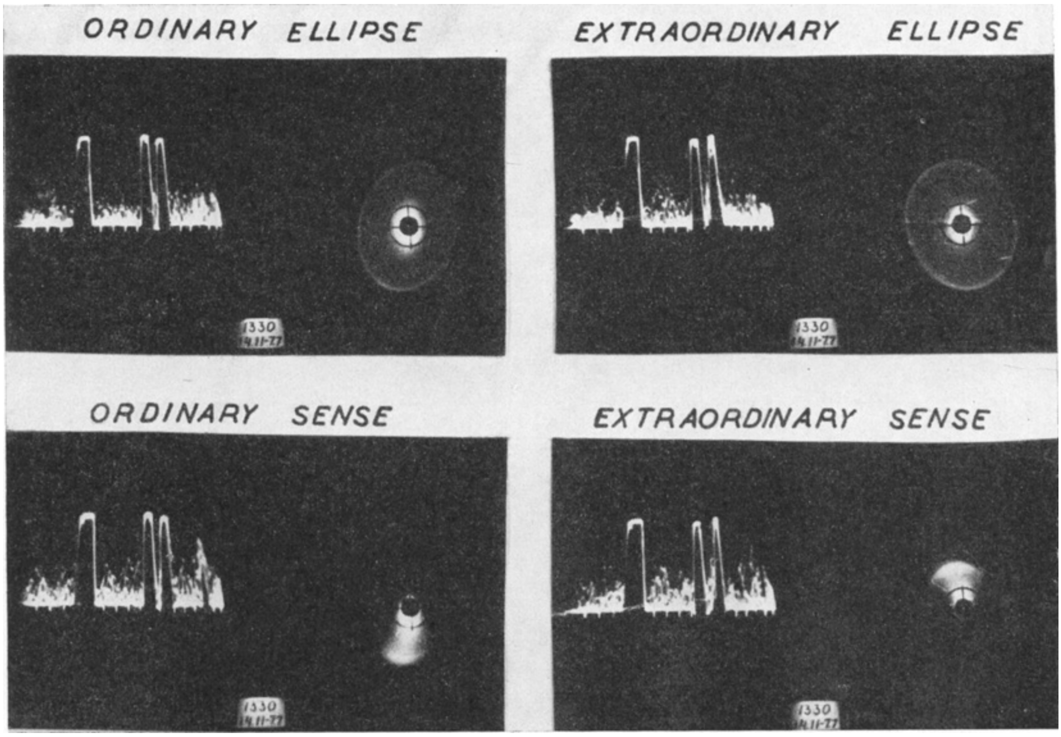

Fig. 3. The complete determination of the state of polarization for an ordinary and an extraordinary echo from the F_2-layer. The observations were made at the Norwegian Defence Research Establishment, Kjeller, on November 14th at 1330 MET on a frequence of 7.7 Mc/s.

In Fig. 2 is illustrated the basic principles of the radio polarimeter. The reception system consists of an HF-direction-finder of standard naval type, described by DE WALDEN, ROCKE and BARRAT (1947). V_1 and V_2 are two cathode ray tubes. V_1 gives the usual echopattern. A timebase is fed to the x-plates, and the signal together with height marks (each 50 km apparent height) is fed to the y-plates. V_2 is opened by an intensity modulation gate-impulse. This gate-voltage is also in reduced form fed to the y-plates of V_1, thus marking by a small pedestal on the trace the intervals in which V_2 is open. By altering the phase and width of the gate-impulse, the wanted signal may be selected. The signals from the two frame aerials are fed to the x- and y-plates of V_2 with conservation of phase relationship. In addition, the signal from the x-plates is shifted 90° in phase, and by superimposing this shifted signal on the gating-impulse of V_2, the sense of rotation may be determined as described above.

3. Results

The radio polarimeter described in section (2) has proved to be well suited for the study of the polarization ellipse, and also for the determination of the sense of rotation of the field vectors.

In Fig. 3 the complete determination of the state of polarization of an ordinary echo as well as an extraordinary one from the F_2-layer is shown.

In Fig. 4 an example is given which shows how the sense of polarization of the z-component is determined. The observation was made on October 24th at 0915 MET on a frequency of 4.4 Mc/s at the Auroral Observatory. In Fig. 4 the h'f-registration is also given which was obtained at 0900 MET. From Figs. 3 and 4 *it appears that the z-component is*

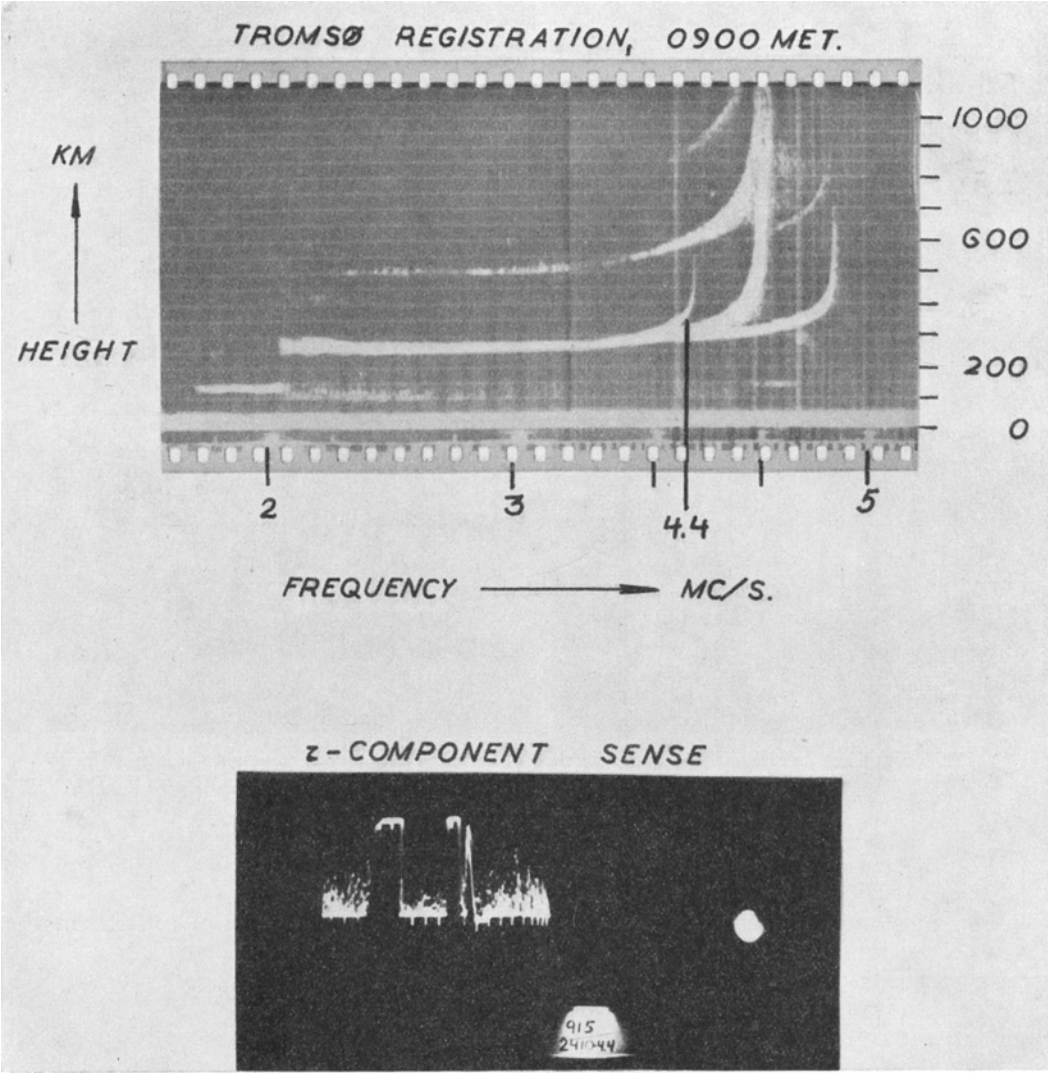

Fig. 4. Determination of the sense of polarization of the z-component. The observation was made at the Auroral Observatory, Tromsö, on October 24th at 0915 MET on a frequency of 4.4 Mc/s. The h'f-registration obtained at 0900 MET is also given.

polarized in the same way as the ordinary component.

The sense of polarization of the z-component was observed regularly during October 1951 at the Auroral Observatory. The observations showed without exception that the z-component was polarized in the same way as the ordinary component. This means that the field vectors is rotating from North to West on the Northern hemisphere.

Acknowledgements

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