THE POLARIZATION STRUCTURE OF TYPE III SOLAR RADIO BURSTS

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Summary

The polarization of type III bursts was measured, using a swept-phase technique, at 40 and 60 Mc/s. The great majority of type III bursts show slight to moderate polarization. The results indicate a double structure for the type III burst—a sharp, intense, drifting feature with relatively strong polarization, and a diffuse background of longer duration with relatively weak or zero polarization.

Introduction

The polarization of solar radio bursts of spectral type III was first studied by Komesaroff (1958), who found that at metre wavelengths some 50% of type III bursts analysed showed fairly strong polarization. Subsequently, Cohen (1959), Akabane and Cohen (1961), and Fritz (1961) found that many type III bursts are weakly linearly or elliptically polarized at 200 Mc/s, and Bhonsle and McNarry (1964) found similar results at 74 Mc/s. The present paper describes an investigation of the detailed temporal variation of polarization during individual type III bursts and groups of bursts; it is based on records taken at 40 and 60 Mc/s with very high time resolution.

Equipment and Method

For the present study the equipment used was of the swept-phase type operating at one or other of the two fixed frequencies, 40 and 60 Mc/s. This system, used jointly for the measurement of source sizes (Weiss and Sheridan 1962) and polarization on a time-sharing basis, was described by Sheridan (1963). For the measurement of polarization, signals from two orthogonal rhombic aerials (linearly polarized) are added and their relative phase is swept through more than 360° in $\frac{1}{4}$ s, the cycle being repeated every $\frac{1}{2}$ s. The resulting sinusoidal interference fringes are recorded on a high-speed paper chart. The system is calibrated by injecting known noise powers from a noise generator. Using this calibration, the degree of modulation $(P_{\max}-P_{\min})/(P_{\max}+P_{\min})$ and the total intensity $(P_{\max}+P_{\min})$ were determined. Alternatively, it was found convenient for some purposes to specify the unmodulated $(P_{\min})$ and modulated $(P_{\max}-P_{\min})$ components.

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Limitation of Records

The measured parameter is M, the degree of modulation, and is related to m, the degree of polarization, by*

$$M = m.2\{(\gamma^2\cos^2\chi+\sin^2\chi)(\cos^2\chi+\gamma^2\sin^2\chi)\}^{\frac{1}{2}}/(1+\gamma^2),$$

where χ is the orientation angle, and γ is the axial ratio of the polarization ellipse.

The degree of modulation M is a lower limit to the degree of polarization m, and is a good measure of m in all cases except those (known to be very rare) when the polarization ellipse is very elongated and lies along one of the aerial directions. In the present paper the measured quantity M is therefore loosely referred to as "degree of polarization". Similarly, we refer to "polarized" and "unpolarized" components of a burst rather than to "modulated" and "unmodulated" components.

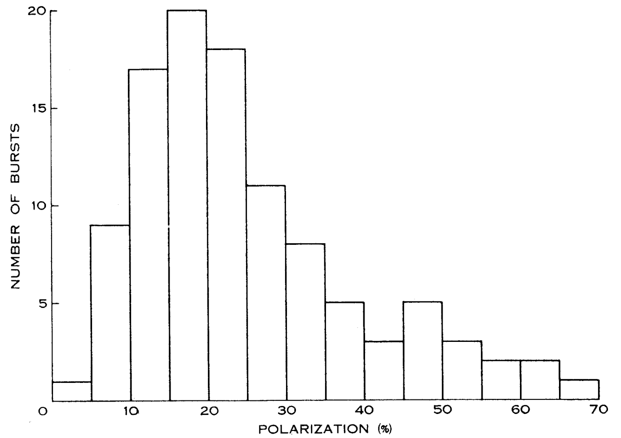

Fig. 1.—Frequency distribution of percentage of polarization of type III bursts (40 and 60 Mc/s observations combined).

The aerials used with the equipment have broad polar diagrams and accept radio waves after reflection from the ground, particularly at low solar elevations. Following Komesaroff (1958), the contribution of ground reflections towards the degree of modulation is assumed to be small; this assumption may be invalid at some angles of elevation and when the degree of polarization is small.

Results

The results of the present paper are based on about 100 type III bursts, during 1960–1962, for which polarization records were available. The great majority of bursts show slight to moderate polarization, while only a small proportion of them show polarization greater than 40%. The mean values of the degree of polarization of the bursts around the phase of maximum intensity are shown in the histogram of Figure 1. These results are generally consistent with those found by other observers, though the polarization is weaker than that implied by Komesaroff's qualitative description.

* The author is indebted to Dr. J. A. Roberts for deriving this relationship.

Examples of the variation of polarization with time during groups of type III bursts are given in Plate 1, where the intensities of polarized and unpolarized components are shown by full and dashed lines respectively. There is seen to be a marked variation in the polarized/unpolarized ratio during the lifetime of individual bursts and groups. Group A consists of a series of very short duration bursts superposed on a fairly weak, diffuse background of longer duration, which provides the finite intensity between sharply defined bursts. The sharp features are strongly polarized ($\sim$ 65–70%) while the diffuse background is less polarized ($\sim$ 50%). The effect is seen more definitely in group B, in which an initial sharp,

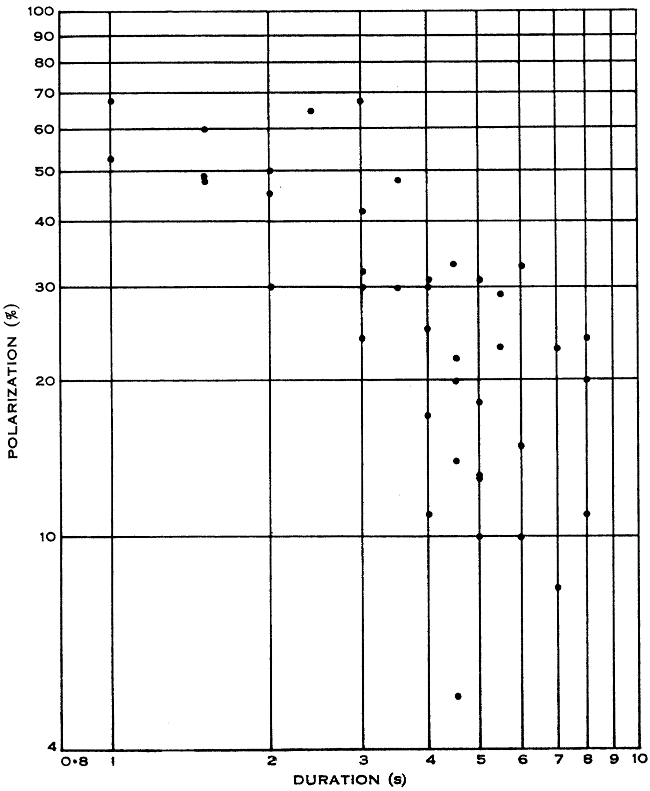

Fig. 2.—Scatter diagram showing the relationship between duration (measured between half-power points) and polarization of the bursts.

intense, burst of strong polarization ($\sim$ 52%) is followed by diffuse bursts or a background of weak polarization ($\sim$ 20%). C is a case of a burst of long duration (the 60 Mc/s profile actually passes through the blobby tail of the burst) and is of very weak polarization throughout.

These examples were chosen as being typical of the cases studied, and the result that the polarization of a burst decreases with its duration t is shown by the scatter diagram of Figure 2. The relation between m and t is approximately of the type $m \propto t^n$, where n is about $-0 \cdot 86$.

No relation was found between the polarization and drift rate of bursts. This result implies that the polarization is not directly related to the motion of the source.

Discussion

The most significant implication of these results is not merely the inverse relationship between polarization and duration, but rather that type III bursts appear to possess a double structure—the sharp, intense, drifting feature with relatively strong polarization, and a diffuse background of longer duration with relatively weak or zero polarization. One may intuitively speculate that the two components could be spatially distinct, e.g. that the sharp feature originates in a region of smaller size than does the diffuse component. Such a structure is suggested by the "core–halo" model of Weiss and Sheridan (1962), but we have no evidence at the present time on the relation between size of the source and polarization.

It is possible, though not obvious from the records, that the diffuse component is in fact a type V burst of very low magnitude. If this proves to be the case, observations of polarization may assist in making an objective distinction between the two burst types, which are, at present, difficult to resolve except in outstanding cases.

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