THE PHYSICAL NATURE OF SPURIOUS POLARIZATION TRANSFORMED FROM THE BACKGROUND NONPOLARIZED RADIATION OF COSMIC EXTENDED RADIO SOURCES

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Polarized radiation of cosmic radio sources carries the important information of the radiation mechanism and magnetic field structure of the sources. The background nonpolarized radiation of extended radio sources may also be partly transformed into spurious polarization. No comprehensive theory concerning the whole physical process of radiation transfer has been developed.

Starting with the Hertz vector potential, we treated the polarization characteristics of three relevant aspects of the problem in a unified way, i.e., the polarization characteristics of the radio sources; the polarization characteristics of the exciting field of the antenna feed system; and the polarization characteristics of the antenna radiation field. A rather clear physical picture of the whole process with analytical formulas has been obtained. The spurious polarization due to nonpolarized radiation of extended radio are calculated from the aperture field excited thereby in various kinds of antenna feed systems. The results are consistent with existing observational facts.

In relation to practical observations, stress is given to the case of using a dual orthogonally polarized horn feed (or horn feed of circular aperture with dual orthogonal outlets). The spurious polarization derived is:

$$P_{sp}(\Phi) = \frac{\int\int\int 2I(\theta,\zeta,\nu)\ U(\theta)\ V(\theta)\ \cos 2(\Phi-\zeta)\ d\zeta d\theta d\nu}{\int\int\int I(\theta,\zeta,\nu)\ [U^2(\theta)+V^2(\theta)]\ d\zeta d\theta d\nu} ,$$

where Φ is the position angle of the dual feed, I is the brightness distribution function of the extended source, θ and ζ are two orthogonal coordinates of a point within the source with respect to the antenna beam axis, $U(\theta)$ and $V(\theta)$ are distribution functions of antenna main field pattern and cross polarization field pattern, respectively, and ν is the observational frequency.

As the formula shows, the spurious polarization changes in a cosine fashion as a function of the position angle of the dual feed. Thus, one can differentiate the spurious polarization from the intrinsic one by changing the position angle of the feed and measuring the amplitude of the cosine curve (see Figure 1).

Also, the spurious polarization can be minimized by minimizing $V(\theta)$.

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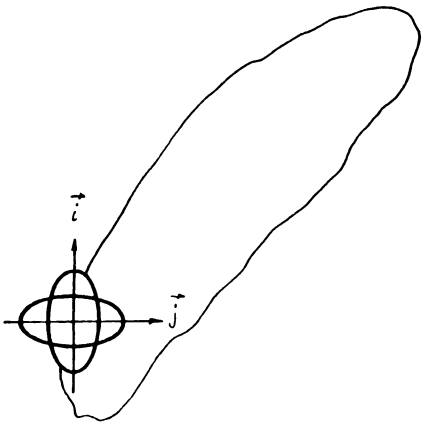

Figure 1. Spurious polarization can be differentiated from the intrinsic one by changing successively the position angle of the dual polarization feed and marking the cosine curve.

The derived formula might serve as a guide to eliminating the spurious polarization due to radiation of an extended source. Also, the systematic method of approach and the understanding obtained may be of use to the analysis of spurious polarization in VLBI polarization measurements.

The derived formula may also open open possibilities of improving and further extending polarization observations to very short wavelengths (i.e., in short mm and submm waves higher than 150–200 GHz). At such wavelengths, the realization of a corrugated horn feed or multimode feed with $V(\theta) = 0$ is quite difficult. Moreover, the losses at such frequencies are excessive. With the method mentioned above, the polarization observation can be extended to very short wavelengths.

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