Variation of the Positional Angle of the Polarization Plane of Radiosources with Time

THE expansion of the volume in which relativistic particles, magnetic fields and ionized gases are contained must be accompanied by both a decrease of the flux density of the synchrotron radio-emission[1] and a change of its polarization parameters. If the radio-emission of such a source is linearly polarized and if the plane of polarization undergoes Faraday rotation φ_s within the source itself and Faraday rotation φ_g in the galactic interstellar medium[2-4], then with a sufficiently rapid expansion of this source, the rate of change of the positional angle will be

$$\dot{\varphi} = \dot{\varphi}_s + \dot{\varphi}_g \simeq 8{\cdot}1 \times 10^5 \lambda^2 \frac{d}{dt} \int_0^R n_e H_r \, dr \qquad (1)$$

But $\varphi_s \gg \varphi_g$ in equation (1) so that the rotation at a distance of one radius of the source is assumed to be the characteristic Faraday rotation with the source. In the simplest model, the source will be transparent at wavelength λ and the non-uniform magnetic field will consist of quasi-uniform regions differing only in the direction of the field and growing with the source without change in relative size. Then if $n_e \propto R^{-3}$ and $H \propto R^{-2}$, we obtain

$$\varphi_s = 8{\cdot}1 \times 10^5 \lambda^2 \left(\frac{R_0}{R}\right)^5 \int_0^R (n_e H_r)_0 \, dr = \varphi_0 \left(\frac{R_0}{R}\right)^4; \qquad (2a)$$

$$\frac{\dot{\varphi}}{\varphi_s} = -4 \frac{\dot{R}}{R} \qquad (2b)$$

If $\dot{\varphi}$, φ and $\dot{R}/R$ are measured (the last by optical means), the rotation in the source and in the Galaxy can be individually determined. The equalities (2) can be considered only to be approximate, because they do not take into account differences in the physical parameters of the elements, their relative movements and the expansion anisotropy.

Let us compare (2*b*) with the rate of secular decrease of the flux density during the expansion. According to Shklovsky[1] $\dot{S}/S = -2\gamma \dot{R}/R$, where $S \propto \lambda\alpha$, $\gamma = 2\alpha + 1$. Here the absence of the injection of relativistic particles is assumed. Substituting from (2*b*), this can be written

$$\frac{\dot{\varphi}/\varphi_s}{\dot{S}/S} = \frac{2}{\gamma} \qquad (3)$$

The accuracy of (3) is limited by the previously mentioned assumptions except for the expansion anisotropy.

The approximations of $\dot{\varphi}$ from equation (3) indicate that this effect can probably be discovered in the course of several years. For Cassiopeia *A*, $\dot{S}/S \simeq -1{\cdot}1$ per cent/yr[5-7] at $\alpha = 0{\cdot}8$ (ref. 8). Boland *et al.*[9] have measured a small linear polarization of Cassiopeia *A* at a wavelength of 2·07 cm. Thus at the wavelength at which $\varphi_s = 1$ rad it is probable that the variation of the positional angle will be $\sim 0{\cdot}5°$/yr. Contrary to the flux density, measurements made on the Earth's surfaces of the permanent positional angle are not subjected to atmospheric extinction at centimetre wavelengths. Because, for the Crab Nebula, $\dot{R}/R = 10^{-3}$/yr, $\varphi \simeq 1$ rad at a wavelength of 21 cm[10] and $\alpha = 0{\cdot}25$ (ref. 8) we find that $\dot{\varphi}0{\cdot}25°$/yr and $\dot{S}/S \lesssim 0{\cdot}3$ per cent/yr. Such an estimate does not take into account the extent of the Faraday rotation or the expansion anisotropy of the Galaxy. Because of the presence of the regular magnetic field and the possible injection of the relativistic particles in the Crab Nebula the value for $\dot{\varphi}$ seems to be more reliable than that for $\dot{S}/S$.

Of particular interest are measurements of $\dot{\varphi}$ for radio-variable quasars. Given these values it would be possible to establish whether the linearly polarized radio-emission comes from the variable central nucleus of the quasar and, if so, to draw some conclusions about the mechanism involved in the generation of variable radio-emission. If the mechanism were to be of the synchrotron type and if the radio variability were to be caused by the expansion of the region in which the radio-emission is generated (refs. 11–13), then in some cases the effect would be sufficiently large to be observed over a period of years. For example, if the Faraday rotation of the Galaxy, the opacity of the sources due to the synchrotron reabsorption and relativistic effects resulting from very fast expansion are not taken into account, the decrease of the flux density of 3*C* 345 during 1964–65 for 20 per cent/yr at a wavelength of 10·6 cm[14] corresponds to $\lesssim 5°$/yr. Here I have taken values for the rotation of about 20 rad/m² (ref. 15) and $\alpha = 0$. Similarly, values for 3*C* 279 are ~ 28 rads/m² for rotation (ref. 15) and $\alpha = 0$ (ref. 16). Thus the increase of flux density for 6 per cent/yr during 1963–65 at a wavelength of 21·2 cm could be accompanied by the change of the positional angle $\dot{\varphi} \lesssim 9°$/yr.

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PLANETARY SCIENCE

Equal Areas of Gondwana and Laurasia

IN a recent communication, Dietz and Sproll[1] have taken the contact between Gondwana and Laurasia as a line along the axis of the Persian Gulf continued through Iraq and Syria to meet the axis of the Mediterranean Sea. Geological evidence does not support this generalization.

Stoecklin (ref. 2, and in a paper presented at the International Colloquium on the Tectonics of the Alpine folded regions of Europe and Asia Minor, held in 1965 at Tiflis, U.S.S.R.) gave reasons for thinking that Arabia and Iran throughout the Palaeozoic era formed part of one stable platform created by Pre-Cambrian orogenics. In the Middle East it is not possible to identify margins for Gondwana and Laurasia in Palaeozoic times. Throughout the Mesozoic and Tertiary eras, however, the well marked Zagros thrust belt, which continues north-west into northern Iraq and Syria, is the geological choice for the northern margin of the Arabian shield. This is a mobile belt of eugeosynclinal type which has suffered two or more orogenies since Jurassic times. The rocks which outcrop in it are different in lithological type from those deposited in the Persian Gulf geosyncline, which subsided gradually during Mesozoic and Lower Tertiary times accumulating some 20,000 ft. of dominantly calcareous sediments which are essentially miogeosynclinal, folded by the Pliocene orogeny, which was most intense in the Zagros thrust belt. It is therefore necessary to place the contact between the shields at least as far north as