TABLE I. Parameters of the galactic magnetic field.

Direction:

Method	Field direction	Distance from Sun
Polarization of galactic radio emission	$l \simeq 50^\circ$	$\leqslant$ 500 pc
Polarization of starlight	$l \simeq 39^\circ.1$	
Orientation of very old nearby supernova remnants	$l \simeq 36^\circ$	
Rotation measures of extragalactic radio sources	$l \simeq 94^\circ$	kiloparsecs
Rotation measures of pulsars	$l \simeq 94^\circ$	

Strength of the regular component $\simeq 2\times10^{-6}$ gauss
Strength of the random component $\simeq 2\times10^{-6}$ gauss
Scale of the variations of the random component $\simeq$ 50 parsec

9. CONCLUDING REMARKS

It is evident that the longitudinal model described in this paper is not the first one and will not be the last one. As the amount and quality of the observational material increases the parameters of the models may change. For the first time it has been tried to combine all observational data which contain enough information to derive insight in the overall galactic magnetic field. For small parts of the sky additional data are available: i.e., polarization of line emission in dense clouds (Zeeman effect). But at present this is insufficient for a study of the large scale properties. On the other hand the existing longitudinal models do fit in the present results while models of a helical kind (e.g., magnetic field lines sound around the spiral arms) do conflict with various observations[10,11,13,19] and can therefore be excluded from further analysis.

The difference in the direction of the galactic magnetic field for the local region and the more distant regions will be studied further. It is not excluded that the galactic magnetic field running along the spiral arms is deformed by the occurrence of nearby supernova explosions of which the remnants are seen as large loops (Sec. 6, Fig. 3).[22]

Note: The English version of this article was supplied to the American Institute of Physics by the author.

---

[1] V. L. Ginzburg and S. I. Surovatskii, Ann. Rev. Astron. and Astrophys. **3**, 297 (1965); the same, Usp. Fiz. Nauk **87**, 65 (1965) [Sov. Phys. Usp. **87**, 65 (1965)].
[2] B. J. Burn, Mon. Not. Roy. Astron. Soc. **133**, 67 (1966).
[3] a) L. Davis, Jr. and J. L. Greenstein, Astrophys. J. **114**, 206 (1951). b) R. C. Bignell, Astron. J. **78**, 1058 (1973).
[4] F. F. Gardner, D. Morris, and J. B. Whiteoak, Austr. J. Phys. **22**, 813 (1969).
[5] S. Mitton, Mon. Not. Roy. Astron. Soc. **155**, 373 (1972).
[6] D. Morris and H. Tabara, Publ. Astron. Soc. Japan **25**, 295 (1973).
[7] J. P. Vallée and P. P. Kronberg, Astron. and Astrophys. **43**, 233 (1975).
[8] W. E. Wright, Ph.D. Thesis (California Institute of Technology, 1973).
[9] G. Goméz-Gonzâlez and M. Guélin, Astron. and Astrophys. **32**, 441 (1974).
[10] R. N. Manchester, Astrophys. J. **172**, 43 (1972).
[11] R. N. Manchester, *ibid.* **188**, 637 (1974).
[12] T. L. Landecker and R. Wielebinski, Austr. J. Phys. Suppl. **16** (1970).
[13] T. A. Th. Spoelstra, Astron. and Astrophys. **21**, 61 (1972).
[14] T. A. Th. Spoelstra, *ibid.* **24**, 149 (1973).
[15] W. N. Brouw and T. A. Th. Spoelstra, Astron. and Astrophys., Suppl. Ser. (1976) (in press).
[16] E. M. Berkhuijsen, Astron. and Astrophys. **14**, 359 (1971).
[17] E. M. Berkhuijsen, W. N. Brouw, C. A. Muller, and J. Tinbergen, Bull. Astron. Inst. Netherlands **17**, 465 (1965).
[18] T. A. Th. Spoelstra, Astron. and Astrophys. **13**, 237 (1974).
[19] T. A. Th. Spoelstra and W. N. Brouw, *ibid.* (1976) (submitted to editor).
[20] T. A. Th. Spoelstra, Paper at Symposium on "Problems of Magnetic Fields in Space" (Crimea, April 6–11, 1976).
[21] J. P. Vallée and P. P. Kronberg, Nature **246**, 49 (1973).

Supplement to the translation

A. A. Ruzmaikin

Usp. Fiz. Nauk **121**, 693–694 (April 1977)

PACS numbers: 98.50.Tq

The magnetic field undoubtedly plays a most important role in phenomena that take place in the Galaxy. It suffices to mention the problem of containment of cosmic rays[1] and the formation of stars.[2] Although the very existence of the Galaxy's magnetic field is universally accepted, real observational proof that makes it possible to assess the magnitude and the geometry of the field appeared only 10–15 years ago. Recently the number and depth of the investigations of the Galaxy's magnetic field has greatly increased because of the great advances in radioastronomy. Foremost among them are polarization investigations of nonthermal (synchrotron) radio emission of the Galaxy, a great contribution to the understanding of which was made by Soviet scientists.[3,4] The most valuable information on the magnetic field is obtained by studying the Faraday rotation of the emission of extragalactic radio sources and quasars. Finally, pulsars turned out to be a splendid magnetometric tool. The ratio of the measure of the Faraday rotation of a pulsar, which is proportional to the integral $\int B_{\parallel} n_e d\lambda$ and to its dispersion measure $\int n_e d\lambda$, yields directly the intensity of the averaged magnetic field of the medium in the path from the pulsar to the observer. The analysis of these methods and of the results obtained with them concerning the magnitude and geometry of the Galaxy's large-scale magnetic field is in fact the subject of the preceding review by the Dutch radio-astronomer T. A. Th. Spoelstra, who is actively engaged in this field.

It must be emphasized, above all, that we are dealing here with the large-scale magnetic field. The study of fields connected with individual galactic objects such as stars or gas clouds, to which other methods can be applied (say the Zeeman effect), is beyond the scope of this review. On the other hand, the term "large-scale" calls for a quantitative definition. Observations have shown (see Spoelstra's article) that the field is regular enough if averaged over scales $\gtrsim 50$ parsec. At smaller scales, appreciable deviations from regularity are noted, with a relative field-fluctuation amplitude $\delta B/B \gtrsim 1$.

It is important to obtain a comparative assessment of the methods used to determine the magnetic field of the Galaxy as given by pulsars and extragalactic radio sources. Although the measure of the Faraday rotation is used in both cases, the interpretation of the results may be entirely different. First, extragalactic sources, in contrast to pulsars, frequently have their own large measures of rotation (up to several hundred rad/m^2). Second, the pulsars are in the Galaxy, but radiation from extragalactic sources negotiates a long path through intergalactic space, where a magnetic field may be present. For a correct interpretation of the contribution of the extragalactic radio sources it is necessary also to take their evolution into account. Pulsars are by the same token convenient in all respects. Unfortunately, however, rotation measures have been obtained so far for approximately three dozen pulsars. The material on the extragalactic sources is incomparably more abundant (several hundred). A convenient and simple method of interpreting the Faraday rotation of extragalactic radio sources is proposed in[5].

Since optical-astronomy data are also used in the review, mention should be made of an interesting method of investigating the geometry of the Galaxy's magnetic field, based on the study of the shapes of galactic nebulae and proposed by the founder of the Crimean Astrophysical Observatory, G. A. Shaĭn.[6] Shaĭn has shown that almost all the large diffuse nebulae and most dust nebulae are very strongly elongated in the direction parallel to the galactic plane along the large-scale magnetic field. He furthermore called attention to the magnetic-field fluctuations several hundred parsec in scale.

Thus, the observation data demonstrate quite definitely that a large-scale magnetic field exists in the Galaxy, with an intensity on the order of 3×10^{-6} G, oriented predominantly along the spiral arms. This raises the question of the origin of this field, a question not considered at all in the preceding review, which is devoted to observational data. It is not a simple task to determine the origin of a magnetic field of such a tremendous scale (several kiloparsec).

The naive approach proposed long ago, in which it is assumed that the observed field of the Galaxy is the compressed part of a very large (or even infinite) common metagalactic field, meets with very serious difficulties. The turbulent ionized-gas motions observed presently and existing in the earlier stage of the evolution of the Galaxy lead inevitably to entanglement and dissipation of the magnetic field within characteristic times shorter than the lifetime of the Galaxy. On the other hand, it seems that the small-scale turbulent motions are incapable of generating a magnetic field of very large scale. However, turbulence in an inhomogeneous rotating galactic disk is not homogeneous and isotropic, but acquires a nonzero spirality (predominance of vortices with definite sign of rotation). In the presence of such a turbulence, as first demonstrated by the German scientists M. Steinbeck, F. Krause, and K. Roedler, the mechanism of the hydromagnetic dynamo of large-scale magnetic fields should be operative. An important role is played also by the differential rotation. That the hydrogmagnetic dynamo operates effectively as applied to the Galaxy was demonstrated in Refs. 7 and 8. For a general review of the problem of the magnetic dynamo as applied to astrophysics see[9].

[1] V. L. Ginzburg and V. S. Ptuskin, Usp. Fiz. Nauk **117**, 585 (1975) [Sov. Phys. Usp. **18**, 931 (1975)].

[2] S. A. Kaplan and S. B. Pikelner, Ann. Rev. Astron. and Astrophys. **12**, 113 (1974).

[3] V. L. Ginzburg, Usp. Fiz. Nauk **51**, 343 (1953).

[4] I. S. Shklovskiĭ, Kosmicheskoe radioizluchenie (Cosmic Radio Emission), M., Gostekhizdat, 1956.

[5] M. A. Ruzmaĭkin and D. D. Sokolov, Preprint No. 91, Inst. Appl. Mech. USSR Acad. Sci., Moscow, 1976.

[6] G. A. Shain, Astron. zh. **32**, 110, 381 (1955).

[7] F. N. Parker, Astrophys. J. **163**, 255 (1971).

[8] S. I. Vaĭnshteĭn and A. A. Ruzmaĭkin, Astron. Zh. **48**, 1154 (1971) [Sov. Astron. **15**, 918 (1972)].

[9] S. I. Vaĭnshtein and Ya. B. Zel'dovich, Usp. Fiz. Nauk **106**, 431 (1972) [Sov. Phys. Usp. **15**, 159 (1972)].

Translated by J. G. Adashko