MAGNETIC FIELD OF ROTATING BODIES

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ABSTRACT. Difficulties of the dynamo and alternative theories of the magnetic field generation are briefly discussed. The correlation between $\eta = \lg \mu/\mu_0$ and $\zeta = \lg J/J_0$ for rotating celestial bodies is considered. μ is the magnetic and J the angular momentum of the body. Existing theories do not explain such a correlation, and it may be an evidence for some new fundamental interaction.

All cosmic bodies - the Sun, planets, stars and galaxies - have magnetic fields. It makes the idea attractive that the field origin is universal. Some concrete realization of this idea has been presented in 1947 by Blackett but it appears in contradiction with observations. The most popular now is the dynamo theory of the field generation. However, side by side with known successes in qualitative explanations of some phenomena it meets many difficulties. It is not clear whether these difficulties are principal or not. The linear dynamo does not give quantitative results. Existing nonlinear models are too primitive. The dynamo seems completely unapplicable to such objects as white dwarfs, Ap stars, neutron stars. The primordial field hypothesis only shifted the problem to the early stage of the object evolution. The low conductivity of some objects excludes the possibility that the observed field is of primordial origin.

There are some other alternative suggestions. For example: the thermomagnetic instability in white dwarfs and neutron stars; the "battery" effect, connected with temperature and chemical inhomogeneities in the body; the inductive interaction of stars in close binary systems, etc. These effects, being effective for some special cases, are by no means universal. So, neither the dynamo nor other suggested mechanisms are applicable to all objects.

However, it seems that there exists some more or less universal correlation between magnetic and angular momenta. One can see that the $(\eta\zeta)$ points in Figure 1 are lying in a narrow band for quite different bodies. The points which are denoted as NS (neutron stawrs), WD (white dwarfs) and other stars do not correspond to some concrete objects but are the middle points for the considered star type distribution. Only

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dipole fields were taken into account. The toroidal field (demonstrating itself as a strong local field on the star surface) is not considered because it may be created from the dipole field by plasma motions. We have assumed that dipole fields of FGKM stars are proportional to their CaII emission (the Sun is a reference point). Magnetic field observations have an accuracy of about 10–100 G for MSS and 10^4 G for WD. We have assumed here that the real field is not far below this limit. The Galaxy dipole field is unknown and is assumed to be ~ 10^{-6}–10^{-7} G. The deflections of the ($\eta\zeta$) values for various observed stars from the middle line in Figure 1 do not exceed two units in the interval of 30 units. This result may be considered as evidence of the universal connection between the rotating bodies and magnetism. The deflections from this connection may be due to concrete processes in the bodies.

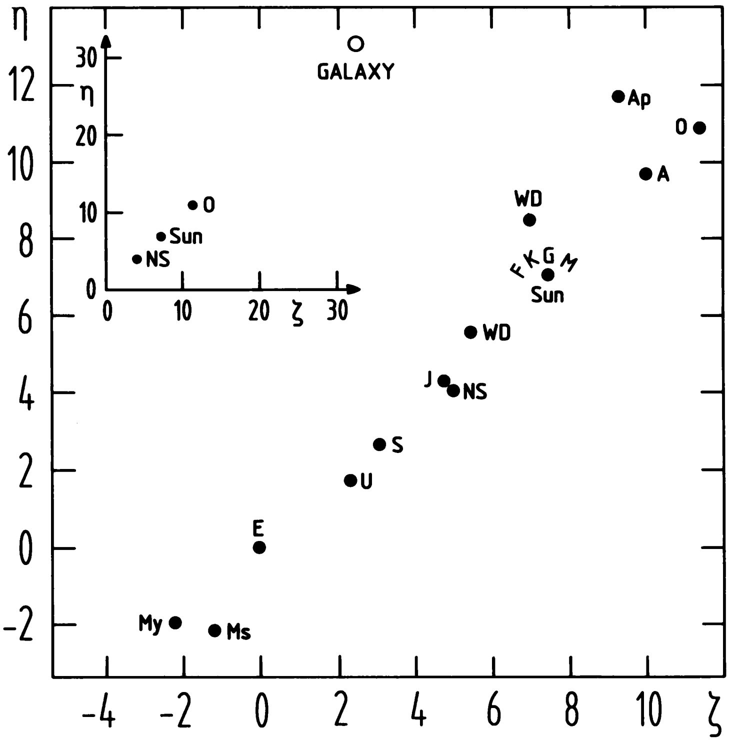

Figure 1: The ($\eta\zeta$) dependence for the planets (J, S, U, E, My, Ms) and various types of stars (O, A, Ap, ..., WD, NS, etc.) where η = lg μ/μ_0, ζ = lg J/J_0.

Reference

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