Babcock's Theory on the Sun's Magnetic Field

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Abstract

A summary of H. W. BABCOCK's most recent thoughts on the sun's magnetic field has been made in the first part of this paper. The second part of the paper gives an evaluation of the difficulties involved as well as some of the more acceptable features of the theory. The theory has, at best, a weak mechanism for energy generation and no method for regeneration of a charge motion responsible for tubes of flux, yet it throws away 99 % of the flux every 11-year cycle. It is suggested that BABCOCK's findings of a separation and diffusion of bipolar magnetic regions (BMR's) as sunspots die, can as well be explained by sinkingof magnetic flux back into the sun, provided the BMR becomes more diffuse with height above the sun, as is the case. The theory admirably takes into account one of the most prominent yet neglected features of the sun's topology, namely, the "long, narrow, characteristically slanted configurations."

H. W. BABCOCK[1] (1961) has proposed a theory to explain many of the observational features of the sun's magnetic field. His theory takes into account SPORER's law, MAUNDER's "butterfly diagram", HALE's polarity law, reversal of the general field of the sun, the preponderance of preceding spots, the long, narrow, characteristically slanted configurations of magnetic regions and facular areas and HALE's chromospheric "whirls". To carry through the mechanism of the theory, five stages in the solar cycle are described. These are, 1st, an initial dipolar field where the lines of force remain in the envelope shallower than 0.1R, but leave the sun and return at the polar caps. Stage 2 amplifies the lines of force because of a stretching of the tubes due to a faster rotating sun in equatorial regions according to an observational law. Next, these tubes of force are twisted, when faster shallower regions of the sun roll the tubes into rope forms. This gives sufficient intensity to agree with observations of sunspot field strengths.

Stage 3 allows local loops or constrictions in the tubes to rise to the solar surface when magnetic pressure, $H^2/8\pi$, gives rise to a flux knot less dense than its surroundings. HALE's polarity laws follow when the tubes break the surface to form bipolar magnetic regions, both in northern and southern hemispheres. The observational law of differential rotation of the sun, because of the greater rotational differential, $dw/d\phi$, at higher latitudes, where ϕ is latitude and w, angular velocity, explains that sufficient magnetic intensity will be built up first at higher latitudes and will gradually work down to lower latitudes in a way similar to the workings of SPORER's law. p spots will predominate because an overriding differential rotation of the shallower layers will tend to push the p section more and more vertical, and will tend to produce a smaller cross-section for the flux ropes in the p section. This same faster shallower layer which twists the tubes into rope forms, gives an explanation for the appearance of the chromospheric