ON THE ORIGIN OF HELICITY IN ACTIVE REGION MAGNETIC FIELDS

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Extended Abstract

The magnetic helicity $\mathcal{H}$ of flux tubes can be separated into twist $\mathcal{T}$ and writhe $\mathcal{W}$ (Moffatt & Ricca 1992). If magnetic flux rises in Ω-shaped loops through the convection zone (Babcock 1961), it acquires writhe through the Coriolis force on internal longitudinal flows (Fan, Fisher, & DeLuca 1993). The tilt θ of active regions with respect to the equator is an observable manifestation of such writhe, at photospheric levels. If $\mathcal{H}$ is conserved, as we expect (Taylor 1974), rising flux should acquire equal and opposite values of $\mathcal{T}$ and $\mathcal{W}$. We expect $\mathcal{W} > 0$ ($\theta < 0$) in the Northern hemisphere, since the leading polarity of active regions tends to be closer to the equator. Hence, we expect $\mathcal{T} < 0$ there.

Using a dataset of Mees Solar Observatory vector magnetograms for about 100 active regions, we have measured the tilt θ, the separation of leading and following polarities L, and the best-fit force-free field parameter α_{best} (proportional to $\mathcal{T}/L$ in a simple model), at large scales. This dataset clearly shows two well-known phenomena, the latitude dependence of θ, known as Joy's law (Hale *et al.* 1919), and the hemispheric dependence of α_{best} (Pevtsov, Canfield & Metcalf 1995). Joy's law can be seen in Fig. 1. For regions that are within $\pm\ 6\sigma$ of Joy's law in our data, we find no relationship between θ/L and α_{best}. However, for regions that strongly disobey Joy's law, we find a clear relationship between θ/L and α_{best}, as shown in Fig 2. However, the sign is opposite the expectation of the previous paragraph. Both figures imply that the twist seen in active region magnetic fields is not a consequence of the rise of flux through the convection zone. We conclude that this twist is the signature of a deep-seated phenomenon, presumably that of the solar dynamo itself.

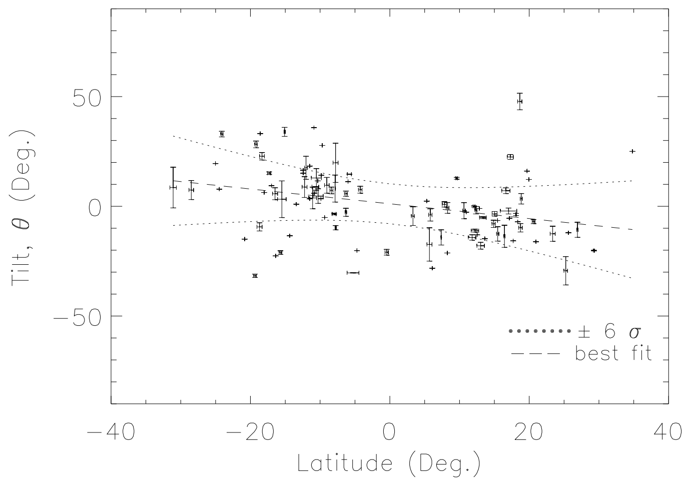

Figure 1. The dependence of the active region tilt on latitude. The dashed line is the best least squares fit to the full dataset (Joy's law). The dotted lines show the $\pm\, 6\sigma$ error band of the fit.

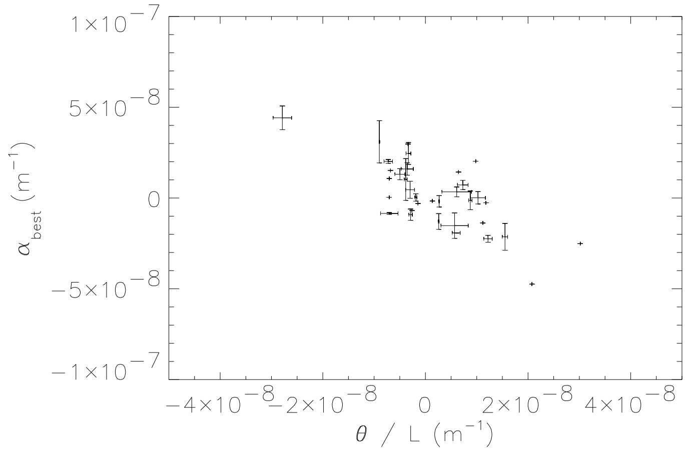

Figure 2. The dependence of α_{best} on the ratio of active region tilt to characteristic length, for the the data points that are beyond $\pm\, 6\sigma$ of the best fit in Figure 1..

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