A SEARCH FOR $\ell = 2$ ASYMMETRIES IN BISON DATA

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An in-depth discussion of the analysis presented here can be found in an up-coming paper (Chaplin *et al.*, 1997).

1. Overview

The presence of a magnetic field will raise the degeneracy in ℓ of the resonant p-mode oscillations, via perturbations resulting from the Lorentz force. These degeneracy-raising effects will give rise to asymmetric mode-multiplet structures. Both Gough & Thompson (1990), and Dziembowski & Goode (1997) have addressed the implications and potential complications that might result from such phenomena. Here, in an attempt to reveal the presence of an asymmetric frequency structure in the low-degree $\ell = 2$ modes, i.e., to measure the asymmetries

$$[1/2 \cdot (\nu_{n,2,m=-2} + \nu_{n,2,m=+2})] - \nu_{n,2,m=0},$$

we have fitted $\ell = 2/0$ pairs in a series of BiSON power spectra generated from Doppler velocity residuals collected between 1990 May 8 and 1996 Dec 31. In all, we fitted: nine 8-month, six 16-month and a single 32-month frequency spectrum spanning the maximum-to-minimum falling phase of solar cycle 22. Gough & Thompson calculated that asymmetries ranging from ≈ 50 to $150\,$nHz might result from a buried magnetic field of the order of 10 MG. Dziembowski & Goode used the BBSO helioseismic data (for $5 \leq \ell \leq 60$) in order to calibrate a model describing the multiplet contamination resulting from the Sun's near-surface magnetic activity. They found that one might expect asymmetries of up to $\sim 200\,$nHz ($n = 20$) at the solar activity maximum. They also indicated that the magnitude of the asymmetries should: increase with increasing n (also indicated by Gough & Thompson), and vary substantially with the solar activity cycle.

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2. Results and discussion

We used maximum likelihood estimators to perform the fitting (χ^2 2-d.o.f. statistics), minimizing for a model where the frequency of each $\ell = 2$ component was allowed to freely float. The asymmetries were extracted from the frequencies returned by the fitting procedure, and the error bars computed from the formal uncertainties on the fitted component frequencies. Even though a series of simulations we performed indicated that there is possibly insufficient resolution in the 8-month spectra to extract asymmetries of the magnitude indicated by Dziembowski & Goode, and Gough & Thompson, we nevertheless include the 8-month results here for completeness. The global, mean asymmetry (i.e., for $10 \leq n \leq 21$) from the 8-month fits is 53 ± 46 nHz (from a total of 42 independent asymmetry measures), and from the 16-month fits 69 ± 32 nHz (from a total of 24 independent asymmetry measures). We also fitted a 32-month spectrum, and obtained asymmetry measures covering the range $10 \leq n \leq 19$. The mean, 32-month asymmetry is 17 ± 31 nHz (8 independent measures). Given the observed precision of the data, we can find no evidence for any statistically significant increase in the measured asymmetries with frequency (i.e., n).

Clearly, we have insufficient numbers of data to measure – to a satisfactory level of precision – asymmetries of the magnitude suggested by Gough & Thompson, and Dziembowski & Goode. Our fits merely place an upper limit to any mean asymmetry – over the range $10 \leq n \leq 21$ – of ≈ 110 to 200 nHz (3σ). [We are reluctant to ascribe any significance to the $\sim 2\sigma$ result returned by the 16-month fits.] Given that our data set covers the full extent of the falling phase of a solar cycle, it is difficult to predict precisely the size of the global mean we might expect to measure. The calculations of Dziembowski & Goode do suggest, however, that our 3σ exclusion threshold may be of a similar magnitude. Regardless, asymmetries of the size suggested by these authors cannot be excluded by our data.

We also tested the 8 and 16-month data for any solar-cycle dependence in the $\ell = 2$ asymmetries, by computing the asymmetry shift per unit change in the 10.7-cm radio flux at each n. If Dziembowski & Goode are correct, then the calculated coefficients should increase with increasing n, reaching ~ 1.7 nHz per unit RF at $n \sim 20$. Our solar-cycle analysis indicates that – as expected – the precision in the measured asymmetries is insufficient to reveal any functional dependence with n. The 8-month coefficients exclude any solar maximum-to-minimum change in the mean asymmetries at the ~ 270 nHz level (1σ), while those from the 16-month data do so at the ~ 200 nHz level (1σ).

References

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