Comment on "Absence of Correlation between the Solar Neutrino Flux and the Sunspot Number"

In Ref. [1], Walther challenged certain statistical tests used to demonstrate an anticorrelation between neutrino flux and solar magnetic indicators. He argued that such tests between series which have dependence or periodicity tend to give "erroneous, highly significant results." His own statistical test yielded a poor significance level, and he concluded that the data are "clearly consistent with a constant neutrino flux when tested against the alternative of a time variation in concert with the solar cycle."

The indicator for the solar cycle that Walther considers in his Letter, viz. sunspot number, is not, however, itself in concert with the magnetic cycle the neutrinos encounter enroute to Earth. Trajectories of the neutrinos detected at Homestake [2] pass within about 5° of the solar disk center, and for the magnetic fields in this region, the cycle is different in timing and shape from that inferred by counting sunspots. In our 1994 paper [3], referenced by Walther, we discussed this and noted the poor significance level in the anticorrelation. When we then investigated correlations with the magnetic flux determined from the Mount Wilson magnetograph data, however, we saw a remarkable trend [3–5] which Walther does not address. Looking at the flux from various zones on the solar disk, we found (a) no correlation when the zone within 25° of disk center is excluded, and (b) an anticorrelation with the fields within this zone, which (c) becomes stronger and more significant as the zone is shrunk towards the disk center. We also found [5] that the trend disappears for unphysical time delays.

This trend is illustrated in the regressions in Fig. 1. Magnetic field data from each of the zones we examined exhibit periodic behavior, and thus could give an overstated correlation as described by Walther. It is remarkable, therefore, that each *a priori* adjustment to better represent the neutrinos' environment also yields a stronger anticorrelation; i.e., that the trend is what the physics would dictate. In view of this, we are puzzled by Walther's decision in [1] to base his argument on sunspots.

We acknowledged [5] that significances are overstated in the Spearman tests we employed, and in the regression in Fig. 1(c), χ^2 only improves by a factor of 2 in going from a flat line to the best fit. Hence the statistics are suggestive, but we do not claim to be proving that the effect is real. The opposite claim [6], however, that the Kamiokande results [7] show the neutrino flux to be constant, has less merit owing to similarly large errors and far less data.

Our result may be a curious coincidence, but the paths of physics are paved with the pursuits of such suggestive patterns. We applaud Walther for pointing out the weakness of the primary statistical tests, yet we feel that it would be a disservice to the physics community to let his criticism bury the entire body of the evidence.

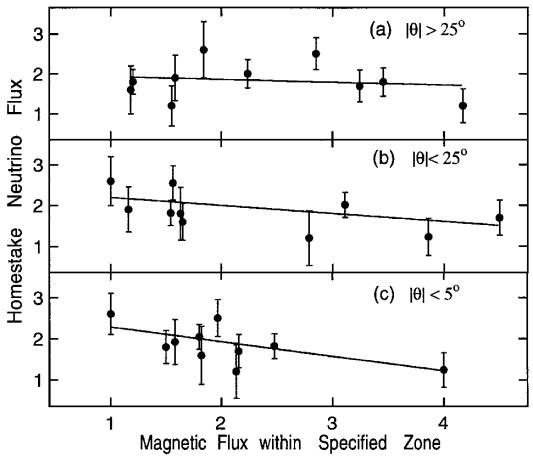

FIG. 1. Regression of neutrino flux vs photospheric magnetic flux, in arbitrary units. The lines show χ^2 best linear fits to 2-yr mean values. Zero slope indicates no correlation and a negative slope indicates anticorrelation.

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[1] G. Walther, Phys. Rev. Lett. **79**, 4522 (1997).
[2] B. T. Cleveland *et al.,* Nucl. Phys. **B38**, 47 (1995); R. Davis (private communication).
[3] D. S. Oakley *et al.,* Astrophys. J. Lett. **437**, 63 (1994).
[4] D. S. Oakley and H. Snodgrass, Bull. Am. Phys. Soc. **40**, 1511 (1995); University of Colorado Nuclear Physics Laboratory Technical Progress Report No. 65, 1996.
[5] D. S. Oakley and H. Snodgrass, Astropart. Phys. **7**, 297 (1997).
[6] Y. Suzuki, Nucl. Phys. **B38**, 54 (1995); D. R. O. Morrison, Part. World **3**, 30 (1992).
[7] K. S. Hirata *et al.,* Phys. Rev. Lett. **65**, 1297 (1990).

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