Löffler, Braun, and Wagner Reply: In our recent Letter [1], we have presented experimental evidence that magnetic correlations in nanostructured magnets extend over many grains with a minimal correlation length at grain sizes of the order of a domain-wall width. Furthermore, we have introduced a generalization of the random-anisotropy model (RAM), which allows us to predict the average correlation length for a given grain size distribution, in good agreement with the experimental data. In the preceding Comment [2], Weissmüller and Michels (WM) claim: (1) that the determination of the grain size via small-angle scattering may be inaccurate, (2) that our model appears to refer to pure nanocrystalline (nc) metals while real grains are surrounded by oxide layers [3], and (3) that the analysis of magnetic correlations via "hard" spheres cannot be reconciled with a description via a RAM. We now demonstrate that these objections do not pertain to our results.

(1) As discussed in Ref. [4], we are fully aware of the possible problems of a grain-size determination via small-angle neutron scattering (SANS). Therefore, we have performed in Ref. [1] an *independent* measurement and determined the grain size from the width of the Bragg peaks in x-ray diffraction. This analysis is insensitive to a pore size distribution which could affect the nuclear length scale determined from SANS. For all our samples the average grain size obtained from SANS agrees within an error of 15% with that obtained from wide-angle x-ray diffraction. It is this agreement which shows that our neutron analysis yields the correct mean grain size. Furthermore, since it is generally accepted that the grain-size *distribution* in inert-gas condensed nc materials is log normal, the only parameter to be determined via SANS is the distribution width $\ln\sigma$ which is known to lie in the interval $\sigma = 1.4-1.9$ [5]. Independent of our determination of the distribution width, it is in this entire interval that our model predicts a distinct minimum of the correlation length as a function of the mean grain size, in agreement with our experimental observations. Therefore WM's remarks about the grain-size distribution are not relevant to our prediction of the minimum of the correlation length. Unrelated to our work, WM raise the issue of interparticle interference. We wish to point out that their statement is based on computer simulations [6] which show a distinct peak in the small-angle structure factor $S(Q)$ at $Q \simeq \pi/R$ with R the average grain radius. Unfortunately, this is in strong disagreement with all measured profiles of nc materials known to date, including those of ball-milled and electrodeposited materials [7], all showing a monotonic decrease of the intensity with increasing Q. Thus, WM's claim of the importance of interparticle interference is entirely unsupported.

(2) The issue of the microscopic origin of the intergrain coupling is irrelevant for our phenomenological model. The introduction of an effective, random intergrain coupling I_{ij} in our generalized RAM accounts for a large variety of exchange mechanisms ranging from grain boundary regions of reduced density or excess spins in oxide layers [8], including high-angle grain boundaries.

(3) Contrary to WM's claim, the assumption of hard spheres is not crucial for our analysis. In fact, we may equivalently start from a *smooth* magnetization configuration with exponentially decaying correlations, i.e., $\langle M^{\alpha}_{\mathbf{r}} M^{\beta}_{\mathbf{r}'}\rangle \propto \delta_{\alpha\beta}\exp\{-|\mathbf{r}-\mathbf{r}'|/\xi\}$, which is often used to describe the correlations in the RAM. This results in the scattering cross section $(d\sigma/d\Omega)_{\mathrm{mag}} \propto 8\pi\xi^3(1+\xi^2\times Q^2)^{-2}$, where ξ is the correlation length. The assumption of hard spheres leads in turn to the cross section proportional to $V_c|F_c(Q)|^2$, where V_c is the (spherical) correlation volume and $F_c(Q) = 3[\sin QR - QR\cos QR]/(QR)^3$ is the structure factor of a sphere with radius R. Both expressions show an asymptotic $(QR)^{-4}$ or $(Q\xi)^{-4}$ behavior in accordance with Porod's law. The crossover occurs at wave vectors $Q \simeq R^{-1}$ or ξ^{-1}, respectively, showing that R and ξ measure one and the same correlation length. Since we have analyzed the particle size distribution in terms of hard spheres, we used the latter also for the analysis of the magnetic correlations. Our analysis shows that the effective exchange constant of nc Fe is similar to that of bulk Fe, "for a number of intergrain couplings exceeding the *percolation* threshold of cluster size L" [1]. In contrast to WM's statement, this, of course, does not imply uniform exchange and includes the possibility of a significant number of weak intergrain couplings.

In summary, we have shown that WM's comments do neither affect the validity of our data analysis nor the appropriateness of our model. Finally, we emphasize that our analysis [1] fully respects the nonlinearity of the magnetization configuration in zero field, while Ref. [7] is restricted to linear deviations from the saturated magnetization state.

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Received 6 December 2000; published 18 September 2001
DOI: 10.1103/PhysRevLett.87.149702
PACS numbers: 75.50.Kj, 61.12.Ex, 75.10.Nr, 75.60.Ch

[1] J. F. Löffler, H. B. Braun, and W. Wagner, Phys. Rev. Lett. **85**, 1990 (2000).
[2] J. Weissmüller and A. Michels, preceding Comment, Phys. Rev. Lett. **87**, 149701 (2001).
[3] J. F. Löffler *et al.,* Phys. Rev. B **57**, 2915 (1998).
[4] J. F. Löffler *et al.,* Mater. Sci. Forum **207–209**, 365 (1996).
[5] C. E. Krill and R. Birringer, Philos. Mag. A **77**, 621 (1998); V. Haas and R. Birringer, Nanostruct. Mater. **1**, 491 (1993).
[6] I. Detemple *et al.,* Scr. Mater. **37**, 1685 (1997).
[7] J. Weissmüller *et al.,* Mater. Res. Soc. Symp. Proc. **457**, 231 (1997).
[8] F. Bødker *et al.,* Phys. Rev. Lett. **72**, 282 (1994).

