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This Week's Citation Classic

Mermin N D & Wagner H. Absence of ferromagnetism or antiferromagnetism in one- or two-dimensional isotropic Heisenberg models.
Phys. Rev. Lett. **17**:1133-6, 1966.
[Laboratory of Atomic and Solid State Physics, Cornell Univ., Ithaca, NY]

It is rigorously proved that at any nonzero temperature, a one- or two-dimensional isotropic spin-S Heisenberg model with finite-range exchange interaction can be neither ferromagnetic nor antiferromagnetic. [The *SCI*® indicates that this paper has been cited in over 595 publications since 1966.]

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"In the summer of 1965, Geoffrey Chester and I were in the Canadian Rockies, talking loudly to scare off grizzlies. Chester shouted that he had recently heard from Pierre Hohenberg that a curious inequality of Bogoliubov could be used to make an apparently rigorous proof that Bose-Einstein condensation or superconductivity could not happen in one or two dimensions. The Bogoliubov result appeared as an original article in a journal otherwise devoted to German translations of Russian papers. It was thus available in virtually no libraries outside of Germany, and I don't remember thinking further about the matter until fall.

"Then, however, Herbert Wagner arrived at Cornell University from Munich with a large manuscript in which he happened to use Bogoliubov's inequality to analyze excitations in a variety of systems. When a paper appeared by Eugene Stanley suggesting there might be a ferromagnetic phase transition in the two-dimensional isotropic Heisenberg model, we realized that Hohenberg's type of argument could be combined with Wagner's analysis to exclude the possibility. We told Michael Fisher about the argument, and he was appalled that we considered ourselves to have *proved* anything. And indeed, we had manipulated frequency integrals of spectral functions without regard to existence or convergence and were somewhat vague on the definition of the magnetization we claimed to prohibit.

"We therefore set out to convince Fisher that we really had proved something, and soon realized that the entire argument could be cast in terms of static thermal equilibrium mean values of operators which were all finite dimensional matrices. We were thus able to refine the argument into an entirely elementary construction of an explicit field dependent bound on the magnetization that vanished with vanishing field. I vividly remember one last round with the three of us at my blackboard, Wagner and I stomping out Fisherian objections at every stage of the proof. I also remember Freeman Dyson visiting Cornell shortly thereafter and being entirely unimpressed, the result being in the class of those evident to any rational being. This, together with the fact that the entire enterprise had taken no more than a week's work, led me to attach very little weight to it.

"However, the article attracted attention. There was interest in Stanley's conjecture; thanks to Fisher's extraordinary obstinacy, our result was a patently rigorous one in an area where little was known with certainty; particle physicists found the approach useful; and the later work of Kosterlitz and Thouless produced a great burst of interest in two-dimensional physics. I would, however, attribute the high citation rate primarily to the fact that our argument was almost immediately labeled the 'Mermin-Wagner Theorem,' and while one can refer the reader to any number of references for an unnamed theorem, a named one carries its own citation.

"Hohenberg's prior work[1] appeared in the next calendar year, and the central role he played in the whole development is now recognized in the leading solid-state physics text.[2] I subsequently made several extensions of the argument which I summarized in a review.[3] Although I had nothing further to do with the subject after 1969, it took almost another decade before I stopped receiving related papers to referee."

1. **Hohenberg P C.** Existence of long-range order in one and two dimensions. *Phys. Rev.* **158**:383-6, 1967.
2. **Ashcroft N W & Mermin N D.** *Solid state physics.* New York: Holt, Rinehart and Winston, 1976. p. 708.
3. **Mermin N D.** Some applications of Bogoliubov's inequality in equilibrium statistical mechanics. *J. Phys. Soc. Jpn.* **26**(Suppl.):203-7, 1969.