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This Week's Citation Classic

Kaiser A B & Doniach S. Temperature-dependent resistivity of dilute alloys with nearly magnetic impurities. *Int. J. Magn.* 1:11-22, 1970.
[Dept. Applied Physics, Stanford University, Stanford, CA]

Impurities which are nearly magnetic in a given host produce localized spin fluctuations. This paper calculates the temperature dependence of the electrical resistivity due to scattering of conduction electrons from these localized spin fluctuations, and explains the experimentally observed behavior in iridium-iron and other alloys. [The *SCI*® indicates that this paper has been cited over 115 times since 1970.]

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"The work described in this paper was done while I was completing my University of London PhD at Stanford. Having gone to London from Wellington on a Commonwealth scholarship to do my PhD, I followed Seb Doniach to Stanford when he and my other supervisor (Martin Zuckermann) emigrated (physicists being more mobile in those days). Doniach suggested I look at spin fluctuations in rhodium-iron alloys, and the effect of a magnetic field in freezing out the spin fluctuation resistivity. I first set about understanding the resistivity due to spin fluctuations without a magnetic field, using the rather nice theoretical model proposed for palladium-nickel alloys by Lederer and Mills[1] a couple of years earlier, and extending their calculations—but I never did get around to the original task of putting a magnetic field in!

"Quite extensive computer calculations produced a linear law for spin fluctuation resistivity at intermediate temperatures (in striking resemblance to experimental data) which I then realized was a general boson scattering result analogous to that in the Bloch-Gruneisen law for electron-phonon resistivity. I ended up by throwing away the computer calculations after finding the right approximations to derive an analytic universal curve. As in most research, with hindsight the final result could have been obtained with only a fraction of the effort actually expended.

"The method of calculation of the falloff in resistivity at higher temperatures was explicitly suggested by Doniach, based on an earlier paper of his,[2] and he also wrote most of the introduction. Spin fluctuations in nearly magnetic systems have been reviewed by Mills *et al.*[3]

"As to why this paper has been cited so frequently, I'm not sure authors can give as balanced an answer as others in the field. A survey of the citations which I have seen indicates that about two-thirds of them are by experimentalists. This suggests that although our paper stimulated some further theoretical work, its main use has been in helping experimentalists understand the resistivity behavior of a wide range of nearly magnetic systems (many of which I'd never heard of when we wrote the paper).

"An interesting feature of the paper is that although it is my most cited, it appeared in probably the least accessible journal of all my papers: the *International Journal of Magnetism* is absent from many physics libraries and ceased publication as such a few years later. Our sending out many preprints of the paper was probably an important factor in the number of citations in the year or two following its publication. It is, however, reassuring that publication in a less accessible journal is clearly not a bar to a large number of citations: perhaps once a lot of citations have appeared in major journals researchers make the effort to dig out the reference. I suspect that the number of citations to our *less* significant papers is more affected by choice of minor journals for publication."

1. **Lederer P & Mills D L.** Electrical resistivity of dilute PdNi alloys; local exchange enhancement effect. *Phys. Rev.* 165:837-44, 1968.
2. **Doniach S.** Theory of inelastic neutron scattering in nearly ferromagnetic metals. *Proc. Phys. Soc.* 91:86-96, 1967.
3. **Mills D L, Béal-Monod M T & Lederer P.** Spin fluctuations around impurities: magnetic and nonmagnetic cases. (Rado G T & Suhl H, eds.) *Magnetism*. New York: Academic Press, 1973. Vol. 5. p. 89-117.