CC/NUMBER 49
DECEMBER 8, 1980

This Week's Citation Classic

Friedel J. Metallic alloys. *Nuovo Cimento* **7**:287-311, 1958. [Sorbonne, Paris, France]

This article stressed these main points: nonlinear screening, including the possibility of bound states; long range oscillations; relation between screening and phase shift; virtual bound states. [The *SCI*® indicates that this paper has been cited over 520 times since 1961.]

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October 20, 1980

"1957 was the year of the first summer school on solid state physics in Varenna, when most of us were still young and swarms of our children were jumping in and out of Lake Como making deafening noises in front of the small lecture room. It was a most representative selection of the then active people in the field. This is probably why my lecture notes, on the electronic structure of alloys published in *Nuovo Cimento* in 1958, have been more cited than the original works of the 1952-56 period they were summarising.[1-4]

"These notes referred mostly to my work on impurities, which started when Nevill Mott suggested to me to look at the problem of hydrogen in metals when I came to Bristol in 1949 to learn solid state physics. My only contact with quantum physics by then was Dirac's book,[5] and I had to work hard to learn about Hartree and Hartree Fock, Mott and Jones, Mott and Sned don, Mott and Massey and all that. I got into deep trouble trying to find a self-consistent solution by the use of a slide rule for monovalent metals: a bound state kept occurring. This showed clearly the poorness of the Born approximation used by Mott in his prewar linearised Thomas Fermi treatment of the problem. I was inclined to be probably too skeptical about linearised treatments, and not to give explicitly at that time the self-consistent linearised formulation which had been later used in the RKKY long range couplings, for electron-electron correlation as well as for describing the scattering of valence electrons by impurities and then by the atoms of the metals themselves. But bound states led me to the questions of how many electrons to put in them (thus to magnetic instability of impurities) and of what self-consistent potential to use for bound electrons (leading to what became the Mott insulator).

"In all cases, long range oscillations kept occurring. When properly explained and taken into account, the total screening charge has to compensate that of the proton. I then discovered experimentally that the screening charge in each spherical harmonic was related to the corresponding phase shift, a pretty good result for slide rule computations. Then after a conversation with John Plaskett, I got one of the demonstrations of that result, which anyway was in essence contained in a paper published by one of my predecessors in Bristol, Kun Huang.[6]

"In the same weak correlation limit, I started working, on leaving Bristol, on the scattering by transitional impurities with de Faget de Casteljau,[7] who left physics after establishing with me the validity in this domain of the concept of virtual bound states."

1. **Friedel J.** The distribution of electrons round impurities in monovalent metals. *Phil. Mag.* **43**:153-89, 1952.
2. ············. Structure éiectronique des impuretés dans les métaux. *Ann. Phys. Paris* **9**:158-202. 1954.
3. ·············. Electronic structure of primary solid solutions in metals. *Advan. Phys.* **3**:446-507, 1954.
4. ············.On some electrical and magnetic properties of metallic solid solutions. *Can. J. Phys.* **34**:1190-211, 1956.
5. **Dirac A M.** *The principles of quantum mechanics.* Oxford: Clarendon Press, 1935. 300 p.
6. **Huang K.** Quantum mechanical calculation of the heat of solution and residual resistance of gold in silver. *Proc. Phys. Soc.* **60**:161-75, 1948.
7. **de Faget de Casteljau P & Friedel J.** Étude de la résistivité et du pouvoir thermoélectrique des impuretés dissoutes dans les métaux nobles. *J. Phys Rad.* **17**:27-32, 1956.