

Citation Classics

Dexter, David L. A theory of sensitized luminescence in solids. *Journal of Chemical Physics* **21**:836-50, 1953.

The probability of electronic energy transfer between atoms is computed for multiple and exchange interactions along the lines of the Forster theory¹ for dipole-dipole coupling. [The *SCI*[®] indicates that this paper was cited 531 times in the period 1961-1975.]

Professor David L Dexter
Department of Physics & Astronomy
University of Rochester
Rochester, New York 14627

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"In the summer of 1952, between jobs in Urbana and Rochester, I spent a few months with the Luminescence Section of the U.S. Naval Research Laboratory (NRL). At that time luminescence in inorganic crystals was studied at a dozen or two laboratories around the world. A small subdivision, investigated primarily by a group in The Netherlands and by J.H. Schulman's group at NRL, was 'sensitized luminescence,' which dealt with the luminescence by an impurity subsequent to excitation of a different impurity (or the host matrix). Schulman introduced me to the subject.

"In the late '40's Forster had developed a theory¹ which had been extremely useful in describing energy transfer between organic molecules in solution. It was based on Fermi's Golden Rule, where the perturbation is the induced dipole-dipole interaction ('near-zone' interaction) between the molecules, and the density of states is provided by nuclear motion and is expressed in terms of an energy overlap integral between the emission band of one molecule and the absorption band of the other. I think that Forster's theory was well known to chemists, but not so much so to solid state physicists in those days. It was clearly

pertinent to the sensitized luminescence problem. In some cases of greatest interest, however, such as the Mn impurity, there was no measurable absorption spectrum for the energy acceptor. Of course 'forbidden' transitions are familiar, reductions in strength by 10^{-6} being not uncommon, so the weakness of absorption was no mystery. A little reflection on the nature of the near zone field shows that the degree of forbidden-ness in transfer probability is much less than in radiative transition probability, so that transfer via forbidden transitions is by no means precluded. Also, the electron exchange interaction may well be important when the dipole-dipole interaction vanishes. I adapted Forster's theory to the case of solids, incorporating ideas of electron-phonon interactions so as to include discussions of Stokes' shifts, temperature dependences, etc., and particularly including higher multipole and exchange interactions. It's rather a long paper, and covers a lot of territory.

"After a few years a lot of people in several disciplines began working on energy transfer problems. Many new effects, such as cooperative absorption, emission, and transfer, were discovered and interpreted in solids, glasses, and solutions, and the field is still very active. A large number of these investigations dealt with rare earth ions, triplet states in organic molecules, and other systems in which the electronic transitions were indeed forbidden by optical selection rules. I suppose people cite my paper as background for the later developments, and as a convenient label for the kind of energy transfer under discussion, e.g., more-or-less resonant transfer without the intervention of free charge carriers or (real) photons.

"In summary, then, Schulman told me what the problem was, Forster had shown how to solve it, and the intrinsic interest in and importance of energy transfer phenomena led to a lot of research activity in this area. Jim Schulman went on to become Director of NRL and is currently with the London Office of Naval Research, and Theodor Forster's untimely death in 1974 terminated a distinguished and still highly productive research career."

REFERENCE

1. **Forster T.** Zwischenmolekulare energiewanderung und fluoreszenz (Intermolecular energy transfer and fluorescence). *Annalen der Physik* **2**:55-77, 1948.