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This Week's Citation Classic

Elliott R J. Theory of optical absorption by excitons. *Phys. Rev.* **108**:1384-9, 1957.

The intensity of optical absorption close to the edge in semiconductors is examined using band theory together with the effective mass approximation for the excitons, to give selection rules for the lines and edges observed. [The *SCI*® indicates that this paper has been cited 447 times since 1961.]

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"After 20 years I still remember this paper as a particularly satisfying piece of research and it is gratifying to find that it is quoted so frequently My interest in the subject arose in the following way. In 1955 I went to the University of Reading where I was the only theorist on the staff of the Physics Department It was therefore natural for me to take an interest in the experimental work going on around me. In particular there was an active group working on the optical properties of solids, mainly on defects in semiconductors and in diamond. To obtain more background in this subject I went in the spring of 1956, to a conference in Paris on luminescence. There I became interested in the remarkable optical properties of certain materials, notably cuprous oxide, reported by Nikitine and his colleagues from Strasbourg which they attributed to excitons. Not everyone was convinced by this explanation because, while the idea of an exciton as an electrically neutral carrier of energy, possibly in the form of a bound hole-electron pair, had been put forward in the 1930s by Frenkel, Mott and others, there were no precise predictions of the optical properties of such entities.

"I made no progress with this problem at the time but that summer I spent a few weeks as a vacation consultant at the Radar Establishment at Malvern. Here MacFarlane and his colleagues had produced some of the purest silicon and germanium then available and among other things were studying their optical properties. The optical absorption edge showed puzzling features and, although quite different from the effects seen in Cu_2O, it occurred to me that these too might be due to excitons

"I therefore set out to extend exciton theory to try and predict optical properties. Kohn, Luttinger and others had recently developed the theory of impurity state in semiconductors and I felt that fhis could be adapted for the purpose. While I was working on the problem Dressselhaus published a paper making the same point In fact, the extension was relatively straightforward and the optical effects could be simply classified. They fell into two main types; direct and indirect, the latter using a phonon to conserve momentum. The selection rules varied depending on whether the transition was dipole allowed or forbidden. On the basis of these simple rules one could predict the essential features of the spectrum; Cu_2O was direct forbidden. Si indirect etc., and relate them to the band structure. One could also predict relative magnitudes and give order of magnitude estimates of the absolute absorption. The details varied, of course, from substance to substance but the basic rules could be used in every case.

"I think it is this aspect of the paper which has made it so much used. Also I think it made excitons respectable by providing a semi-quantitative theory with selection rules. It was no longer possible to pass off these interesting effects as due to impurities."