Mapping of Recombination Mechanisms in Hydrogenated Amorphous Silicon with Coherent Spin Control -- a 21st Century Approach to Unsolved 20th Century Solar Cell Efficiency Challenges

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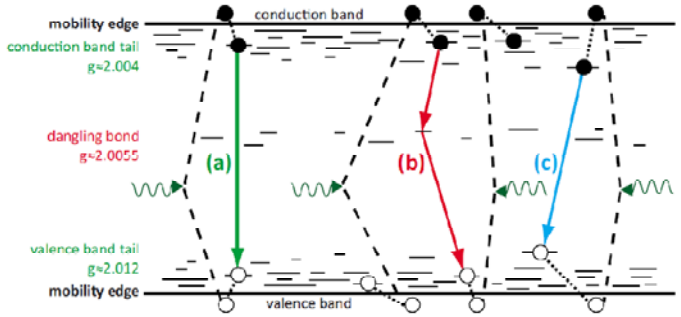
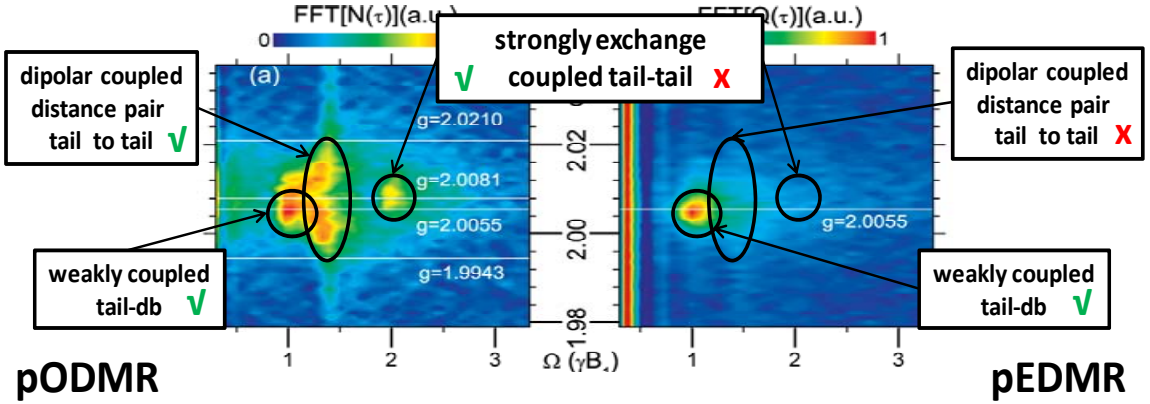
Optical and electrical detection of coherently manipulated spin-dependent transition rates is used to gain microscopic understanding of charge carrier recombination in hydrogenated amorphous silicon (a-Si:H), a thin film semiconductor used for solar cell applications.

The sketch illustrates the complexity of the a-Si:H band gap and some recombination processes. The experiment allowed a categorization ("mapping") of these mechanisms into Lande-(*g*)-factors and charge carrier coupling regimes. This mapping helps to answer a long debated question about which of the recombination processes are geminate (without effect on conductivity) and which are non-geminate (with effect on conductivity), which is of significance for the understanding of solar cell efficiency limitations.





Plots of the optically (a) and electrically (b) detected recombination rate as a function of the magnetic resonance induced spin-Rabi nutation frequency Ω and the g-factor of the recombining charge carriers. The measurements were conducted on identical a-Si:H films and under identical conditions.

The optically detected measurement shows a variety of different recombination channels while the electrically detected data reveals recombination for one g-factor and one nutation frequency only. Thus, most of the optically detected recombination does not influence the conductivity. It is geminate recombination.