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Coulomb interactions in organic semiconductors

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Pi-conjugated organic molecules and polymers now provide a set of well-performing semiconductors that support devices, including light-emitting diodes (LEDs) as used in smart-phone displays and lighting, field-effect transistors (FETs) and photovoltaic diodes (PVs). These are attractive materials to manufacture, particularly for these large-area applications, but, as I will explore in this talk, their electronic properties are very different from standard semiconductors such as silicon. Firstly, electronic overlap between adjacent molecules is relatively poor, and this often drives localization of electronic states. Secondly, dielectric screening is weak so that Coulomb interactions between charges and spin exchange energies are large. Management of transport and of excited state spin is fundamental for efficient LED and solar cells operation. I will discuss some of our recent work in Cambridge. I will discuss the use of spin ½ 'radical' semiconductors where we can light emission to the spin doublet excited state that avoid non-radiative spin triplet states. In contrast, I will present recent results that show triplet formation still limits the performance of the better-performing organic solar cells based on non-fullerene acceptors such as 'Y6'.