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Observation of triplet level crossing in single crystal organic transistors using magneto conductance at room temperature

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Organic semiconductors provide a unique set of properties that provide for the manufacture of large and flexible LED screens and photovoltaic arrays. In order to lower the operating voltages of organic LEDs (OLEDs) and improve efficiency above the Shockley-Queisser limit in organic photovoltaic (OPV) devices, quantum processes such as singlet fission/triplet fusion can be exploited. Singlet fission, where two triplet excitons (or polaron pairs) are generated from one photon, may help to boost the solar conversion efficiency of these van der Waals bounded materials. In the reverse process, triplets created by charge carriers injected through electrical contacts in OLEDs are suggested to be upconverted to higher energy singlets and reduce the on-voltage. Though singlet fission/triplet fusion processes show promise in enhancing efficiency, understanding of triplet and singlet state control in electronic devices where paired charges can recombine at defect and interface sites must be further explored.

In order to better understand the tie between singlet fission/triplet fusion and its related multiexcitonic intermediate state process, we present results from a study of magnetoconductance of single crystal tetracene field effect transistors. We find that we can tune the amount of current in the transistor by changing the magnitude of an applied magnetic field under light illumination. In addition, results show that the transistor magnetocurrent dips in performance at around 10mT and 42 mT at a certain applied field angle, which can be understood by considering sub-energy level crossings of paired triplet states due to the Zeeman effect and magnetic dipolar interaction. These dips in performance illustrate the direct correspondence between quantum processes and device performance, and demonstrate the possibility of OLED and OPV device control by using magnetic fields.