**Intrinsic Magnetoresistance in Organic Light-Emitting Diodes**

**AN INVESTIGATION OF ORGANIC MAGNETORESISTANCE IN OLEDs MADE WITH P3HT**

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**Why Organic Electronics?**

- Lightweight, thin, and efficient
- Improved picture quality
- Lower production costs
- Flexible devices due to the amorphous molecular structure of the organic layer

**Objective and Procedure**

- Determine if current theoretical models of Organic Magnetoresistance (OMAR) can explain observed magnetoresistance in organic light-emitting diodes (OLEDs) made with the organic polymer P3HT.
- Fabricate OLEDs without exposing the devices to damaging x-rays (thermal evaporation) and observe the unaltered, intrinsic OMAR effects.
- Attempt to fit our data with two existing OMAR models

**Organic Light-Emitting Diodes (OLEDs)**

- OLED structure

**How OLEDs Work**

- Light is emitted when an electron (e-) and hole (h+) recombine.
- The organic layer is an insulator, so it does not have intrinsic charge carriers. As a result, an anode and cathode are needed to facilitate the injection of charge.

**Organic Magnetoresistance (OMAR)**

- Electrical resistance of OLEDs changes in a magnetic field.
- We measure magnetoresistance by looking at magneto-conductance.
- Magneto-conductance is expressed as a percentage and is given by:

\[
\text{Magneto-conductance} \% = \left( \frac{I(B) - I(0)}{I(0)} \right) \times 100\%
\]

- I(B) is the current at a particular magnetic field (B) and I(0) is the current through the device when the applied magnetic field is zero Tesla.
- The potential (voltage) applied across the device remains constant.

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**Theoretical Models**

- There are two leading models that attempt to explain OMAR, the Bipolaron Model and the Electron-Hole Model.

**Bipolaron Model**

- Spin Blocking reduces the current at high B-fields.
- Pauli Exclusion Principle prevents charges with the same spin from occupying the same state.
- Applied magnetic field aligns the spins of the charge carriers.
- Most likely to increase the resistance, and decrease the conductance.

**Electron-Hole Model**

- Excitons are bound electron-hole pairs that can be in either a singlet state or a triplet state.
- Recombination is spin dependent; high recombination decreases magneto-conductance.
- Singlet state: net spin = 0, recombination more likely
- Triplet state: net spin = 1, recombination less likely
- At high B-fields, the spins of the holes and electrons are likely to be aligned, forming triplet, rather than singlet, excitons.
- Less recombination allows more charge carriers to stay in the device, increasing the magneto-conductance.

**Data fitting functions**

- OMAR is believed to be able to be described by either of the following empirical line shapes.

\[
\text{Magneto-conductance} (%) = \frac{Ax^2}{x^2 + B^2} \times 100\%
\]

which is referred to as a "Fully Saturated" curve, or

\[
\text{Magneto-conductance} (%) = \frac{Cx^2}{(Dx)^2} \times 100\%
\]

which is referred to as a "Weakly Saturated" curve, where x is the magnetic field and A, B, C, and D are constants.

**Experimental Results**

**Discussion**

- It appears that the combination of the existing models and fitting functions may be able to explain the small OMAR effects observed.
- Although we can fit of our data with the combination of fitting functions, our fits do not have consistent values for the constant terms.
- More data collection and analysis will be required to determine if the combination of functions is necessary and sufficient to describe the observed OMAR effects.

**Works Cited**


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