

# Impact of triplet excitons on photocurrent in diF TES ADT single crystal transistors

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## Improving traditional devices

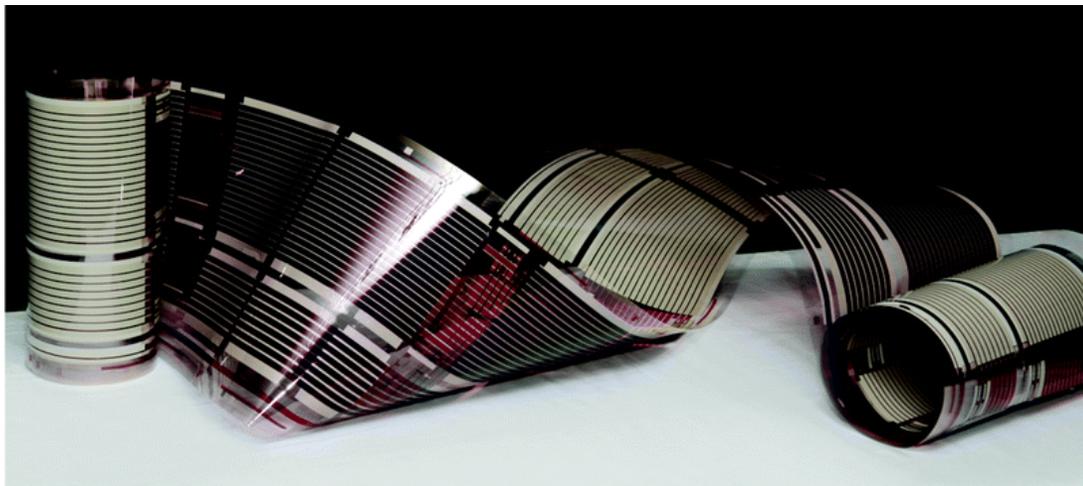
- Flexible
- Printable
- “Cheap”



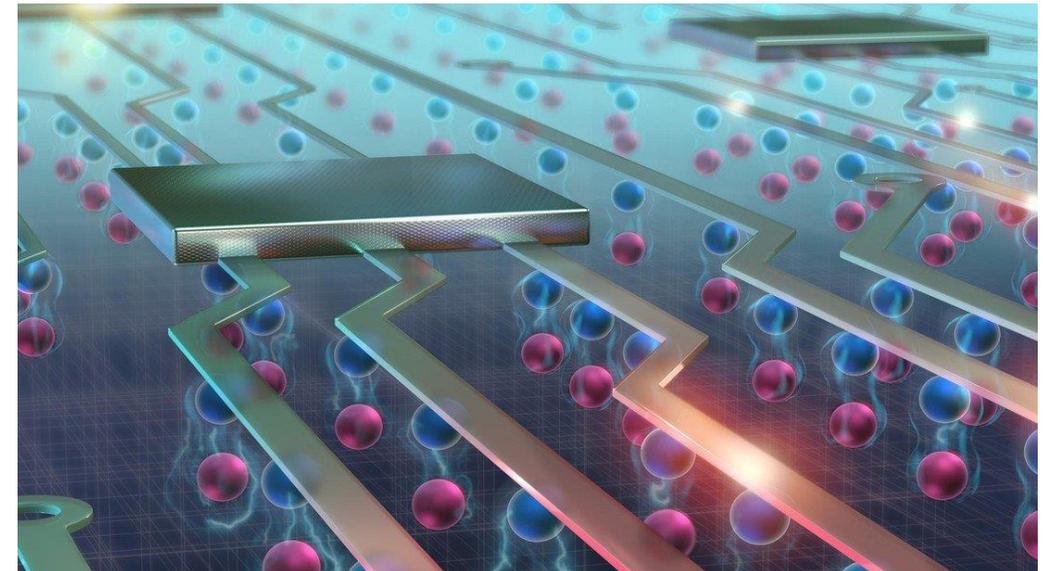
## Future electronics

QIS and neuromorphic computing

- Spintronics
- Exciton based devices
- Logic in memory

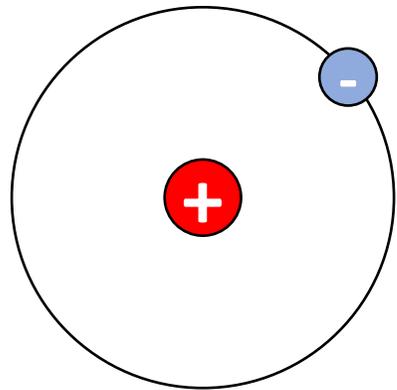
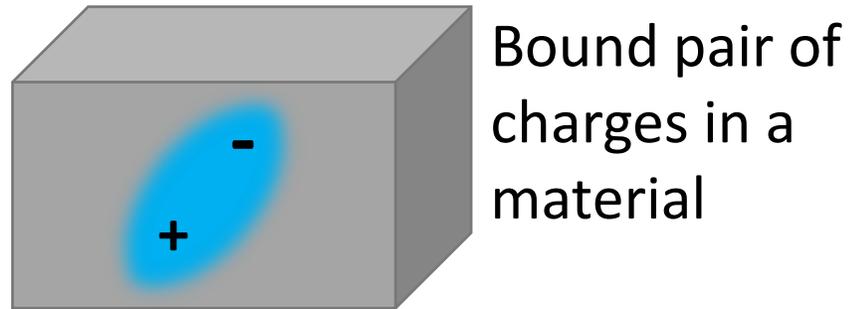


Nanoscale, 2015, 7, 9570



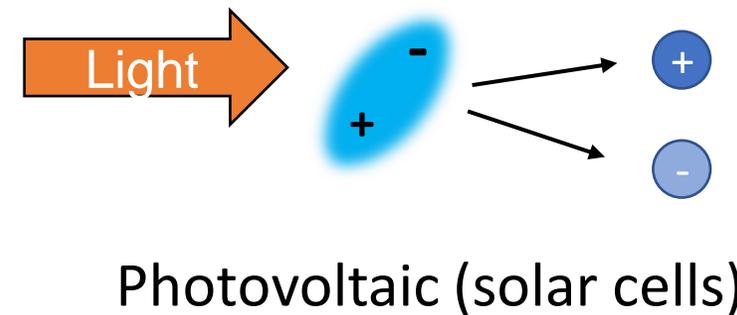
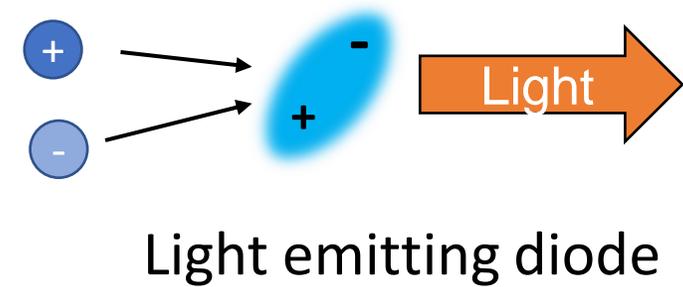
Credit: Mediacom

## What are they?



Hydrogen atom

## How do they form?

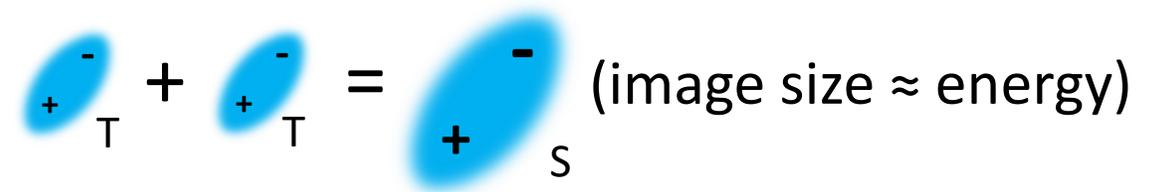


# Neat things about excitons in organics

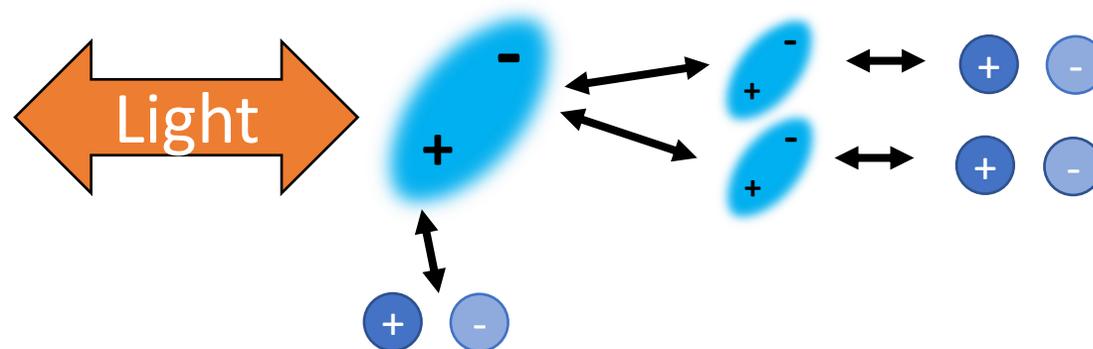
## Lifetime

Long lived at room temperature: 100's  $\mu\text{s}$   
(in GaAs qdot: 10's ps)

## Fission and fusion (some organics)

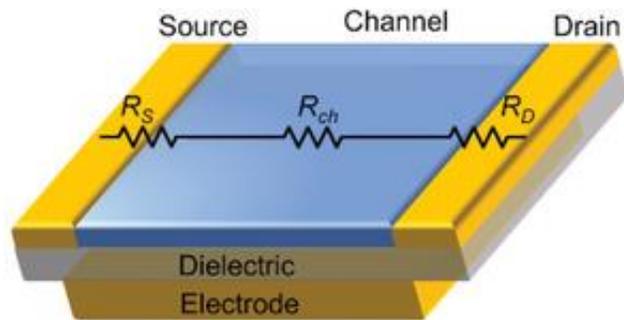


Triplets	Singlets
<ul style="list-style-type: none"><li>- Live longer</li><li>- No light interaction</li><li>- Spin</li></ul>	<ul style="list-style-type: none"><li>- Higher energy</li><li>- Light interaction</li><li>- No spin</li></ul>



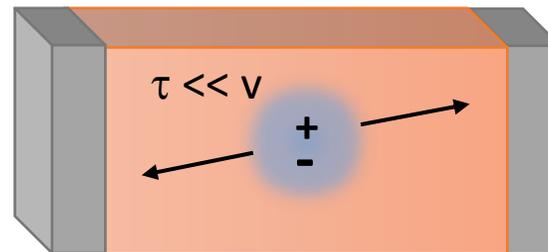
Smith and Michl., *Annu. Rev. Phys. Chem.*, **64**, 361 (2013).

Loss of information through interfaces

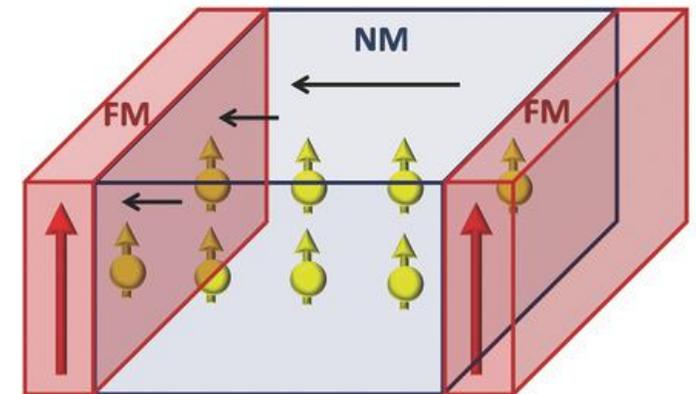


Waldrip, Jurchescu, Gundlach & Bittle *Adv. Funct. Mater.* 30, 1904576 (2020).

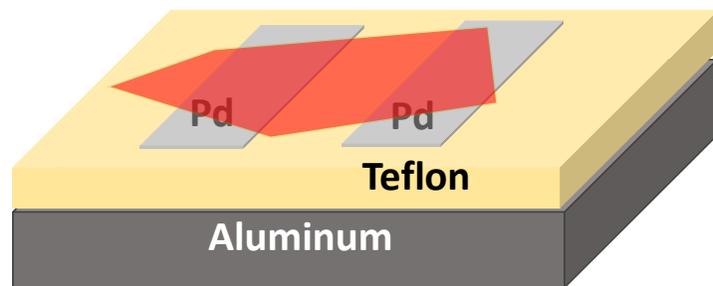
Timing of important processes



Access to specific information carriers



Jang & Richter *Adv. Mater.* 29 (2017).



We can still probe some of the properties of spin and excitons in traditional devices with experimental design

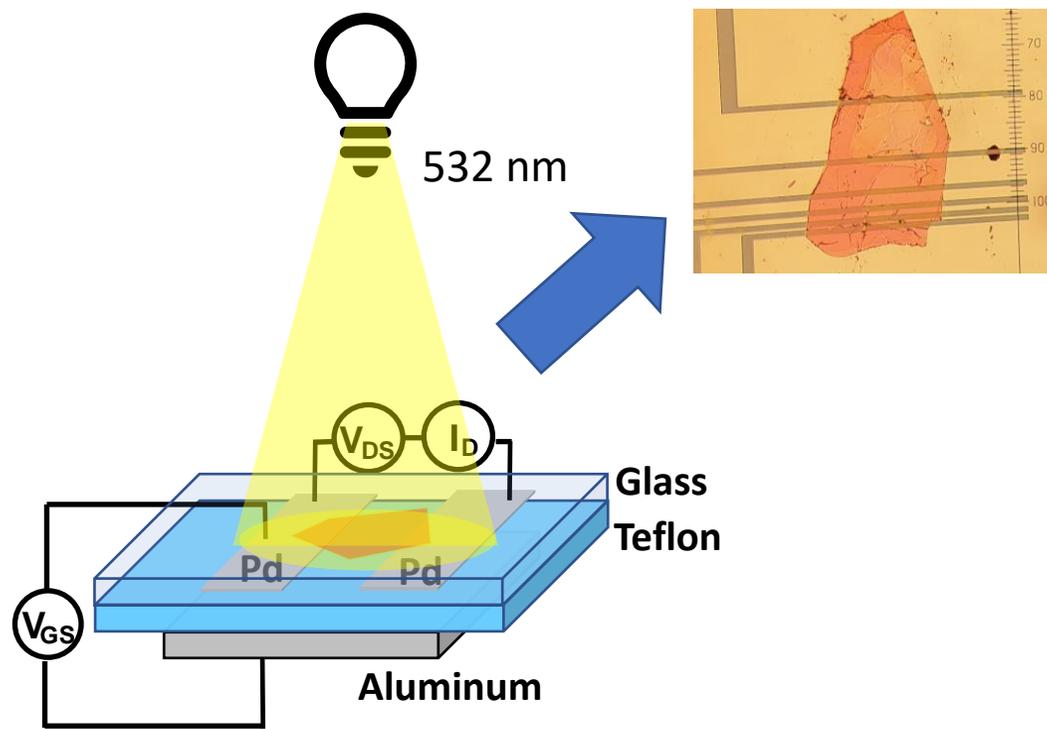


Possible to implement within existing structures



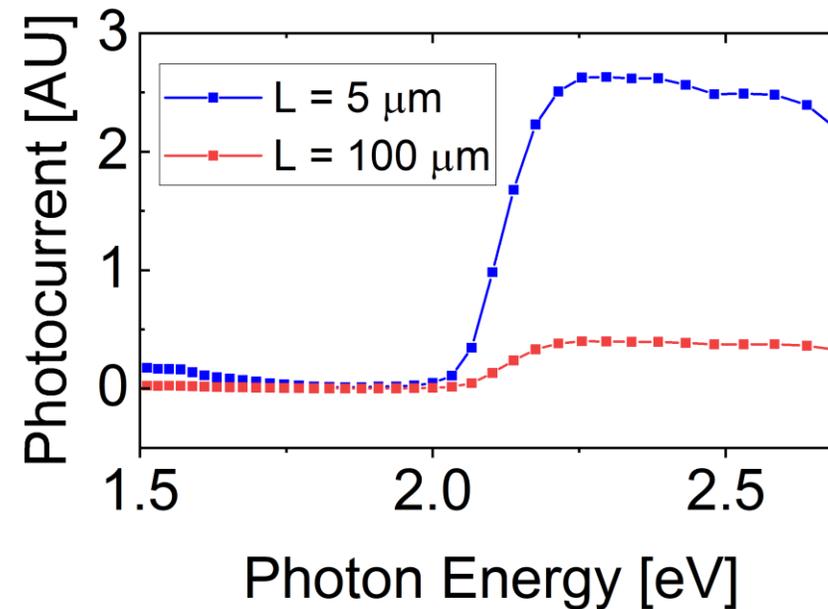
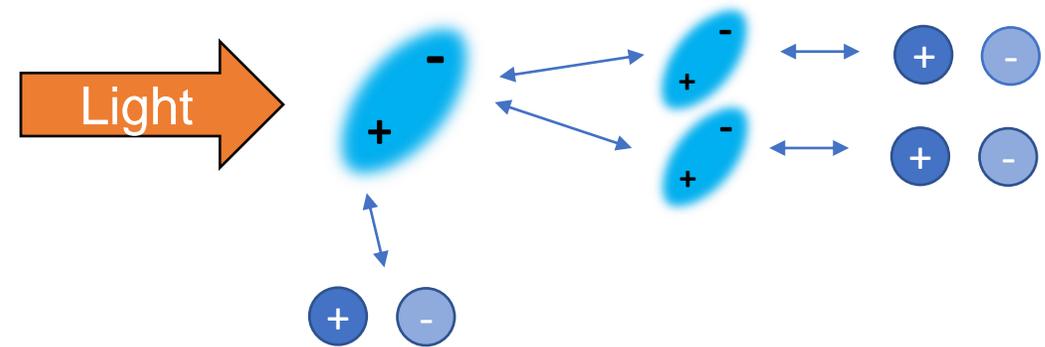
Measurement platform well known

# Photocurrent in diF TES ADT

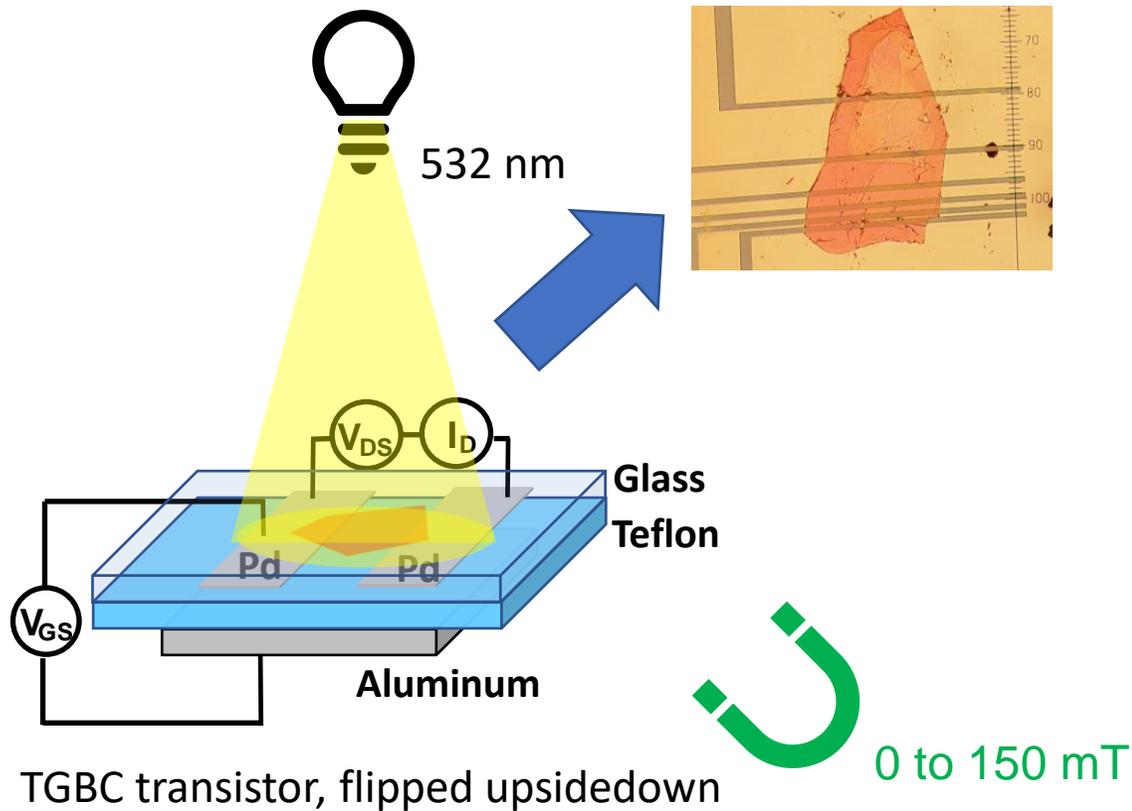


TGBC transistor, flipped upside-down

Jang, Bittle, et al., ACS Nano **2019**, 13, 616.

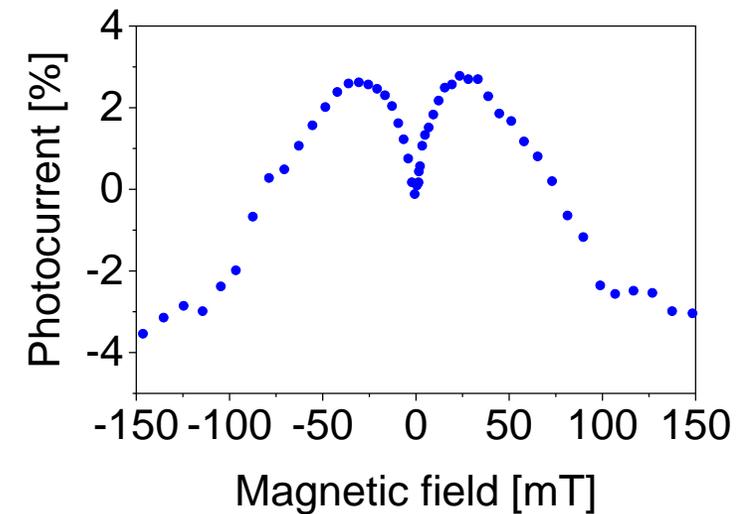
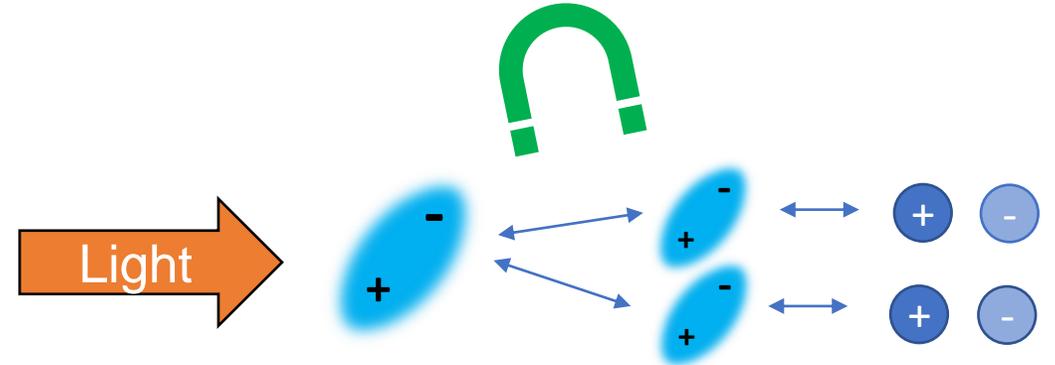


# Magneto-Photocurrent in diF TES ADT

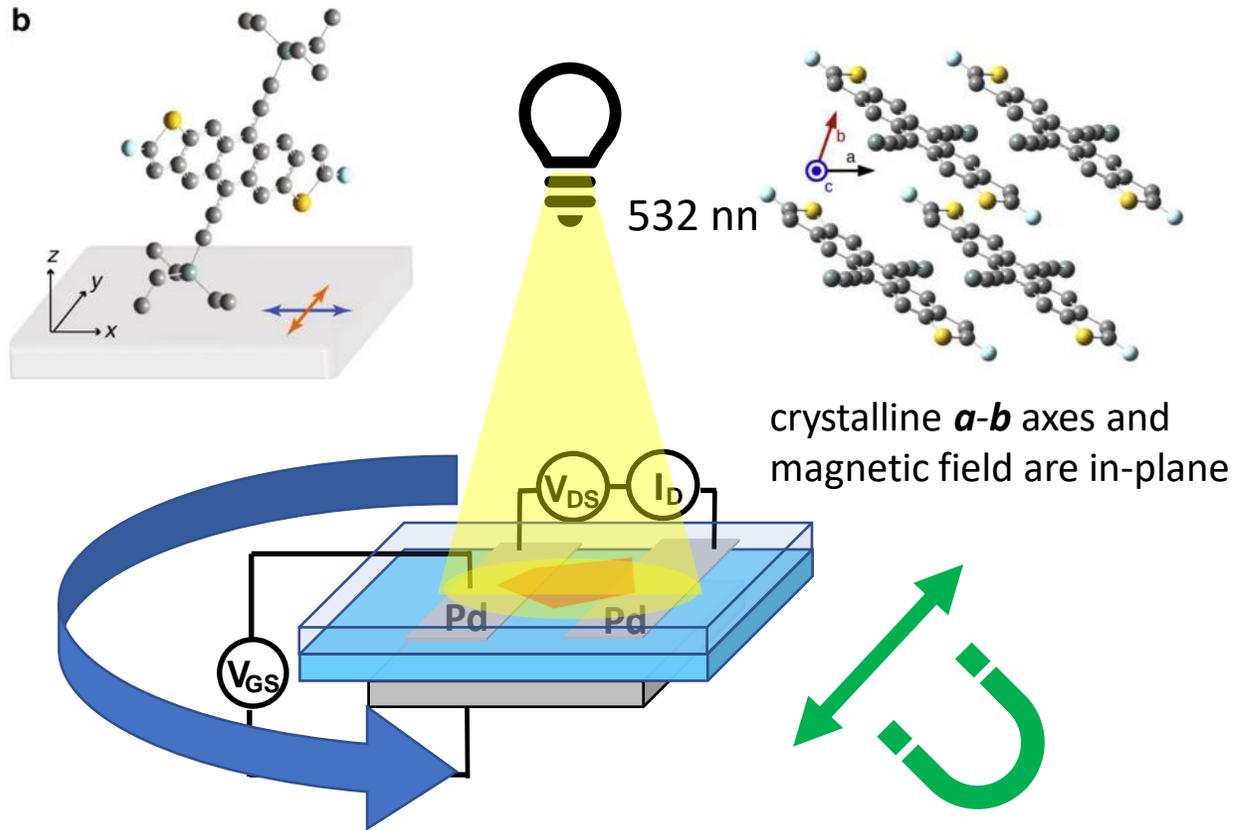


TGBC transistor, flipped upsidedown

Jang, Bittle, et al., ACS Nano **2019**, 13, 616.

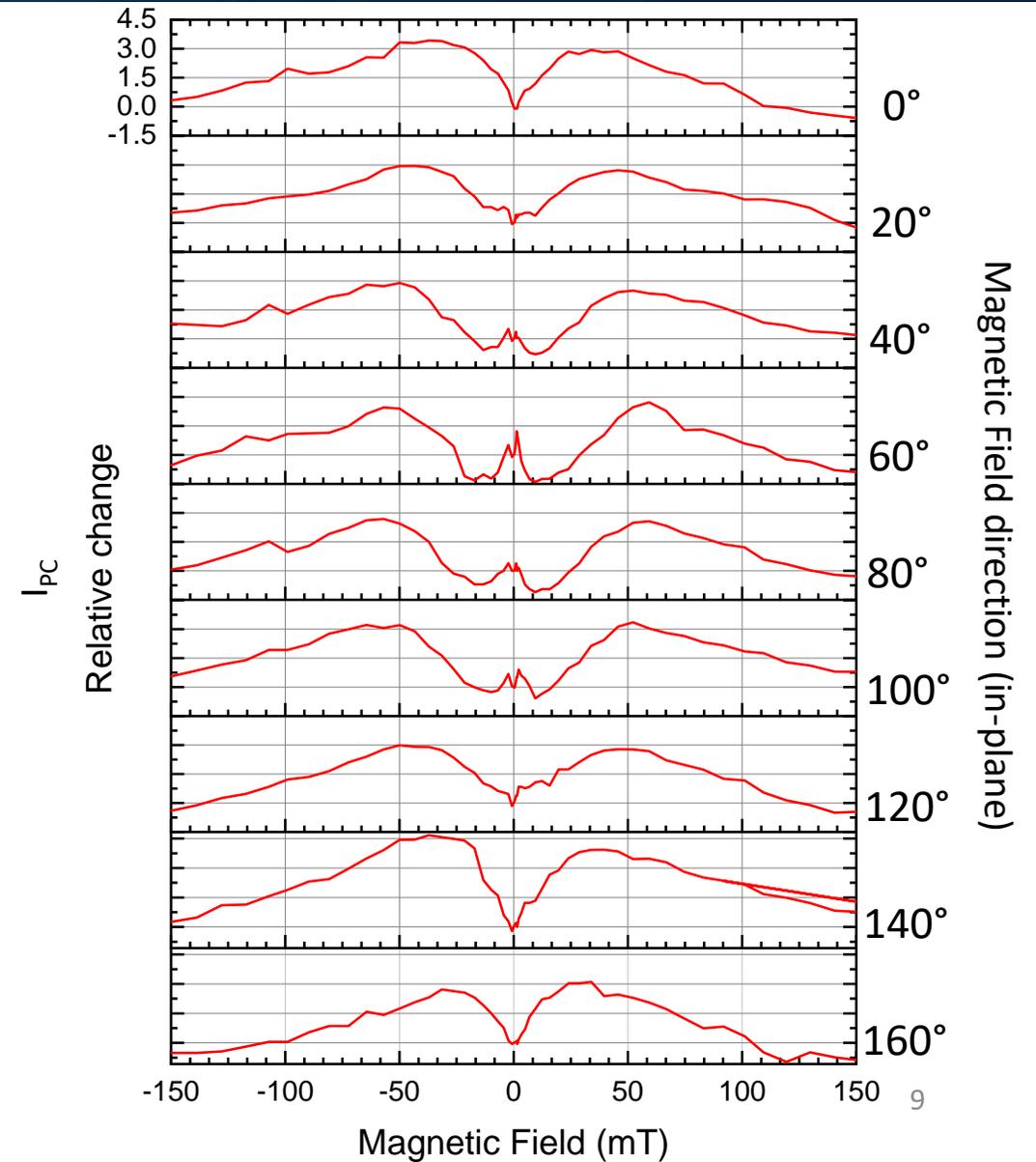


# $I_{PC}$ in an oriented B-field



Huang et al. Communications Chemistry  
2, 22 (2019)

Paudel et al. Organic Electronics  
67, 311-319 (2019)

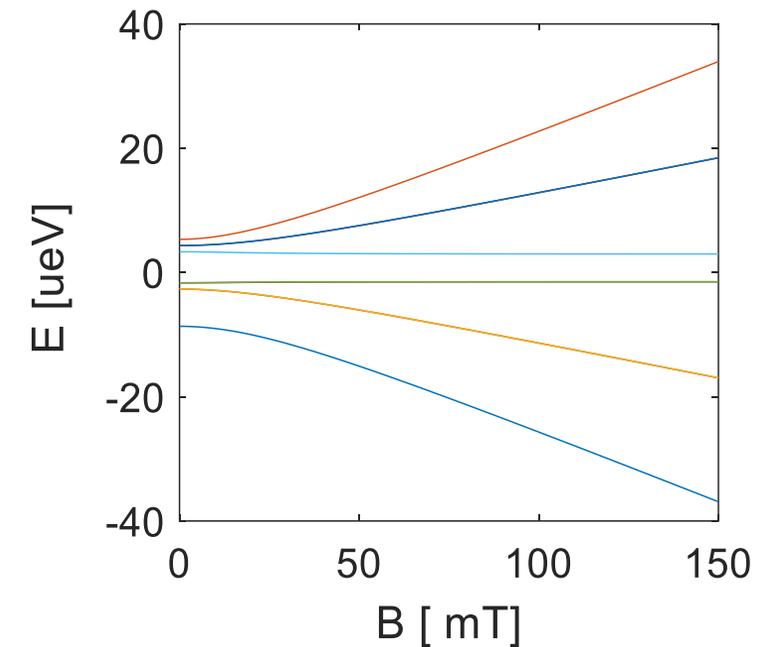
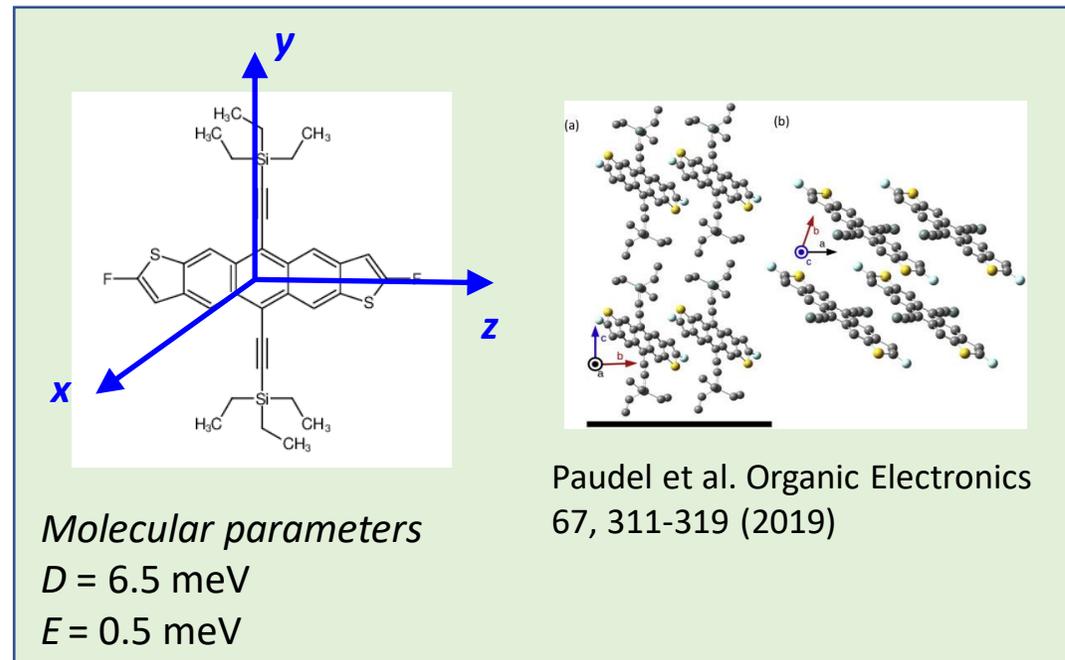
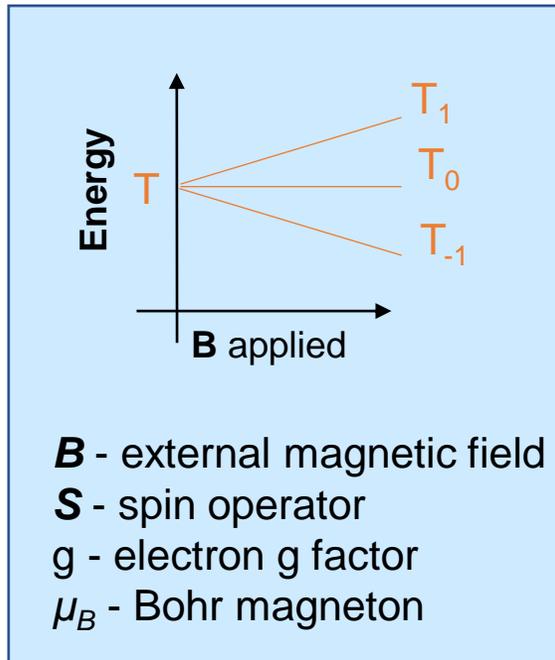


# Magnetic fields and the triplet energy

$$H = g\mu_B \mathbf{B} \cdot \mathbf{S} + D \left[ S_z^2 - \frac{S(S+1)}{3} \right] + E[S_x^2 - S_y^2]$$

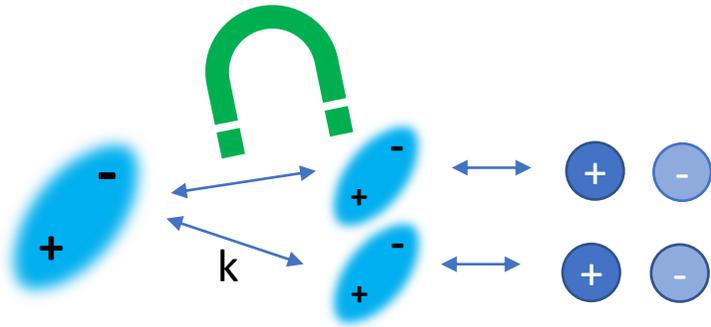
Zeeman interaction

Triplet dipolar interaction



EasySpin- Stoll and Schweiger J. Magn. Reson. **2006** 178(1), 42

# Photocurrent from triplet density



Triplet density  $\Phi_T(B) = \sum_{m,n} |P_{mn}^s|^2 \frac{k^2}{k^2 + (\omega_m - \omega_n)^2} - 1$

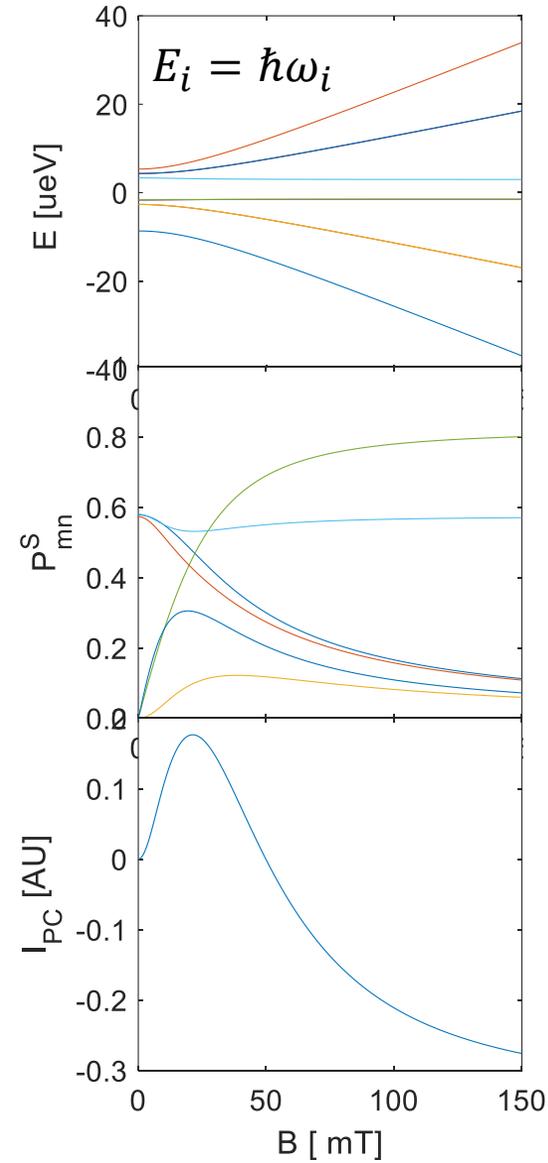
Photocurrent  $I_{PC} \propto \frac{\Phi_T(B) - \Phi_T(0)}{\Phi_T(0)}$

Jang, Bittle, et al., ACS Nano **2019**, 13, 616.

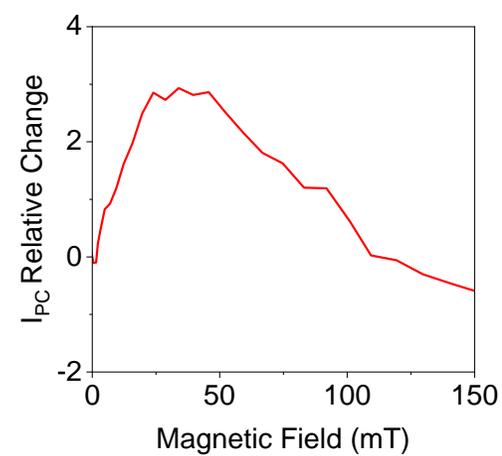
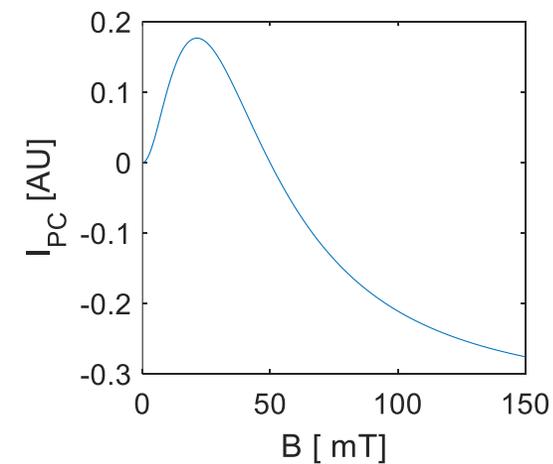
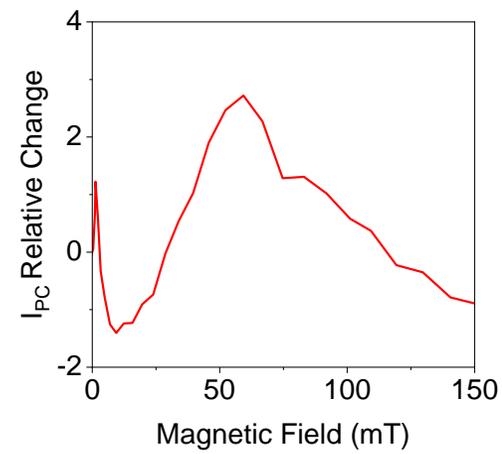
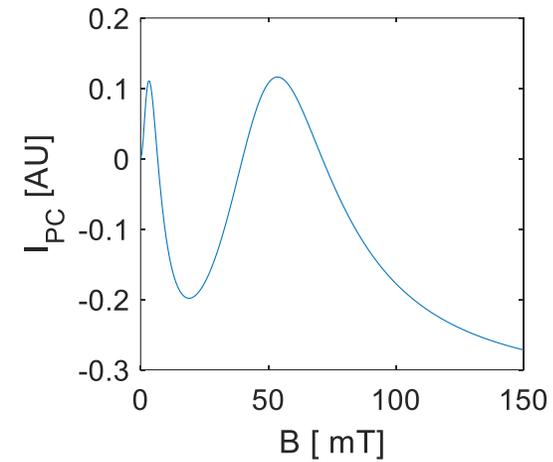
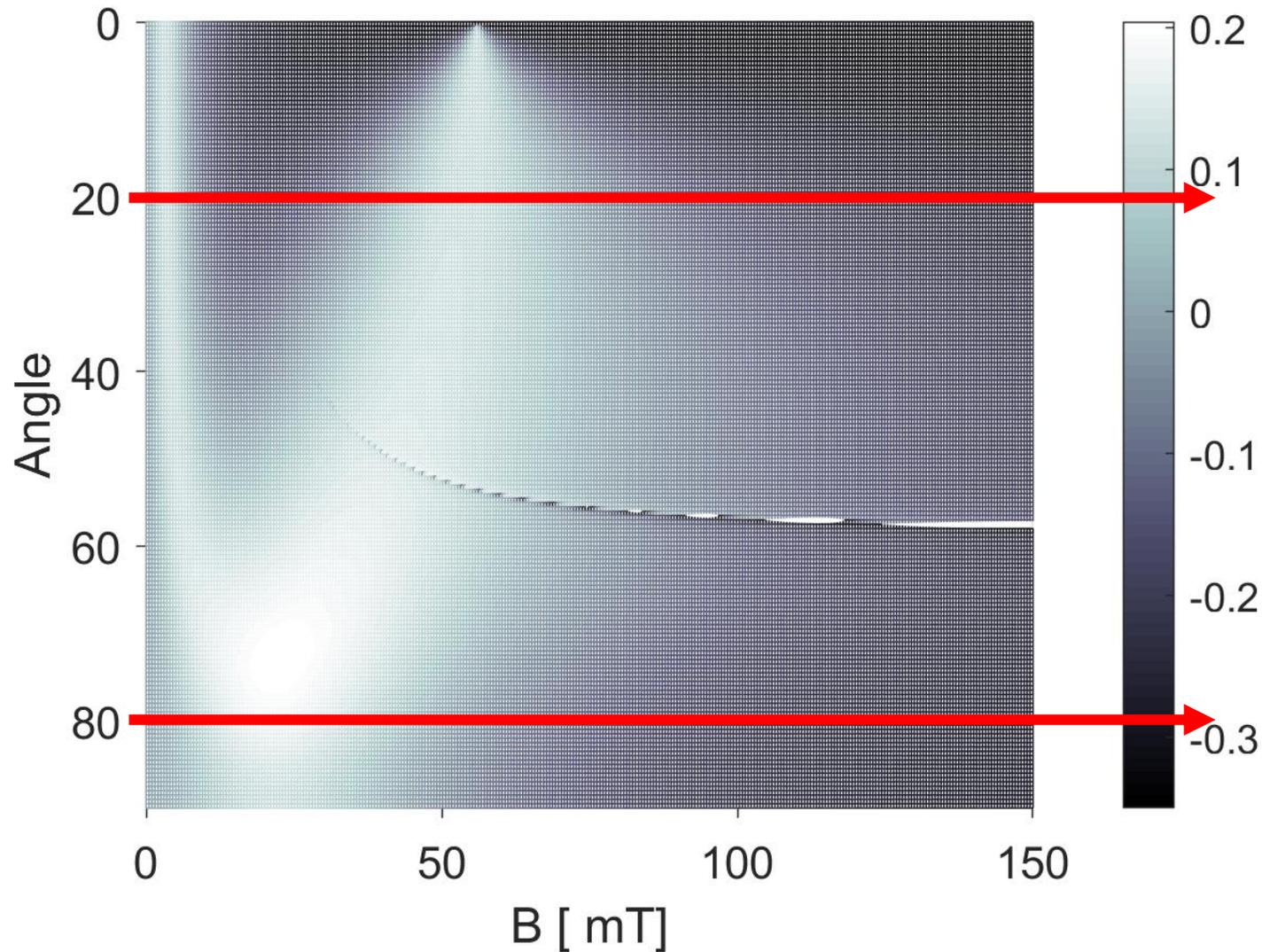
EasySpin- Stoll and Schweiger J. Magn. Reson. **2006** 178(1), 42

Burdett et al., Chem. Phys. Lett. **2013**, 1, 585

... and thanks to Paul Haney!

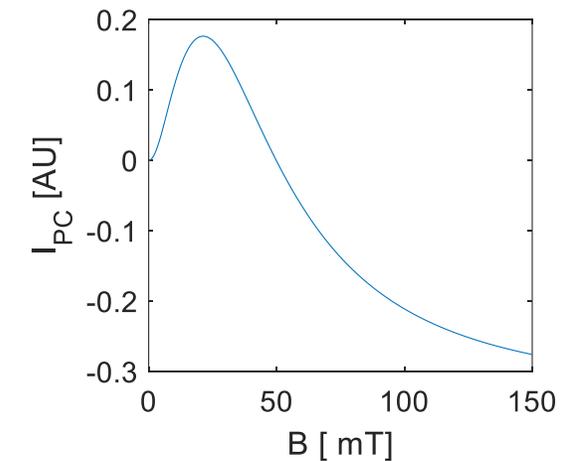
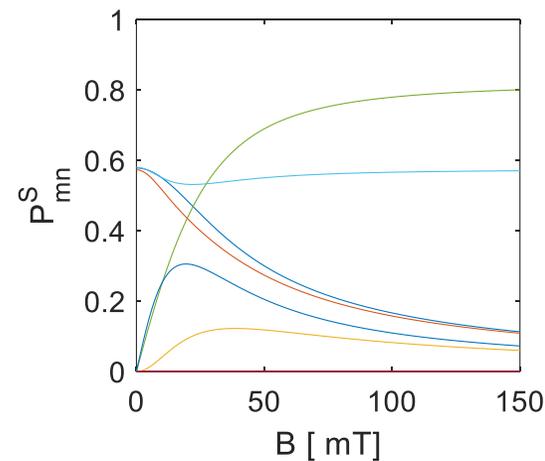
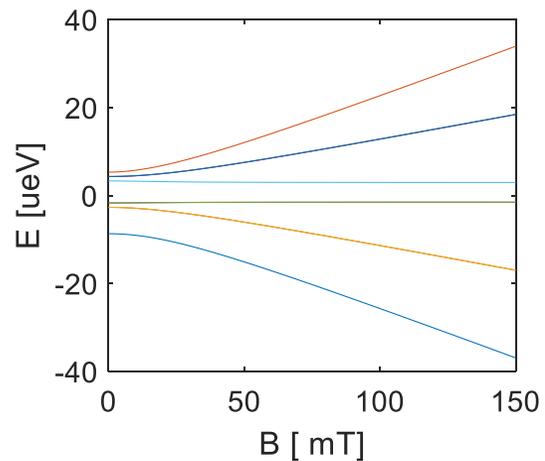
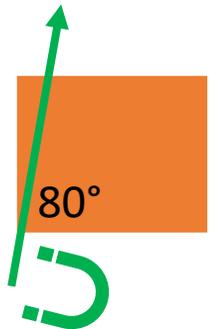
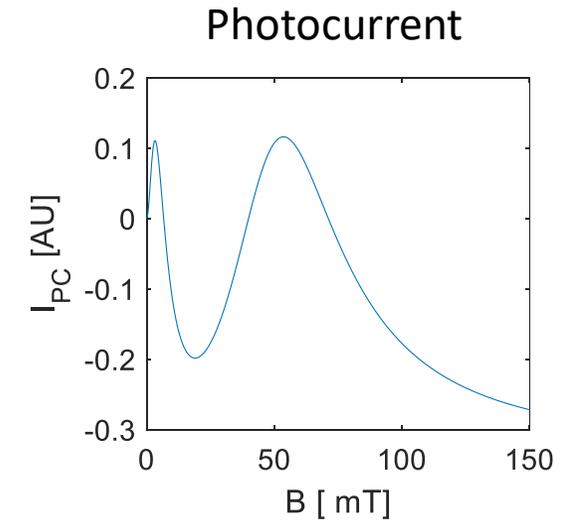
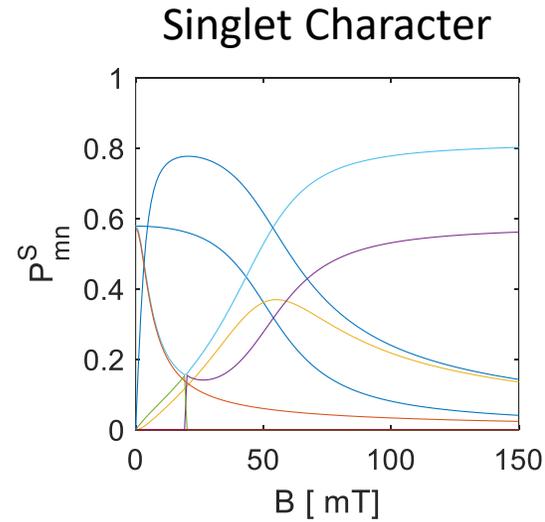
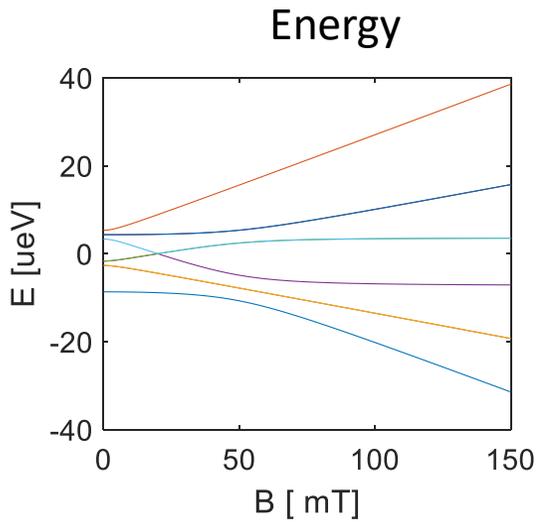
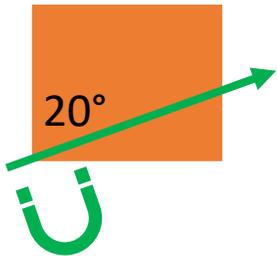


# Model and data correlation

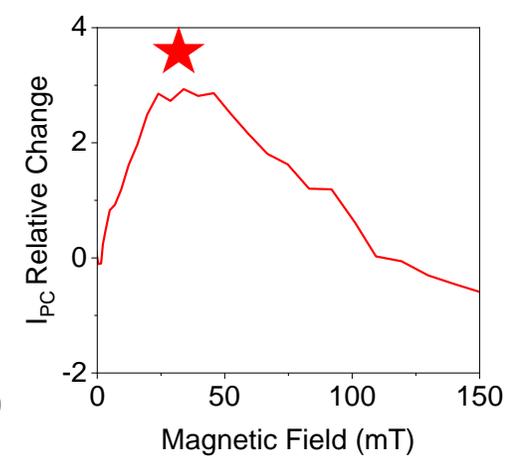
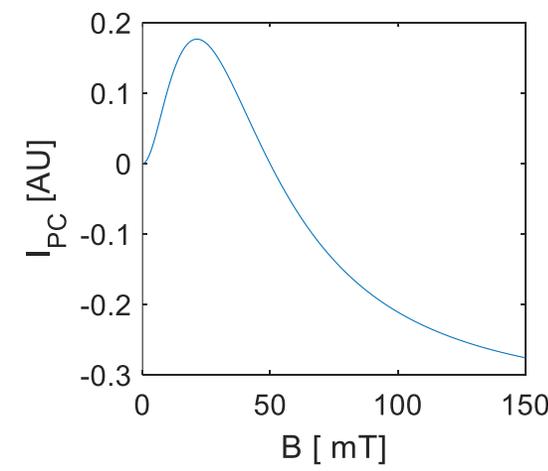
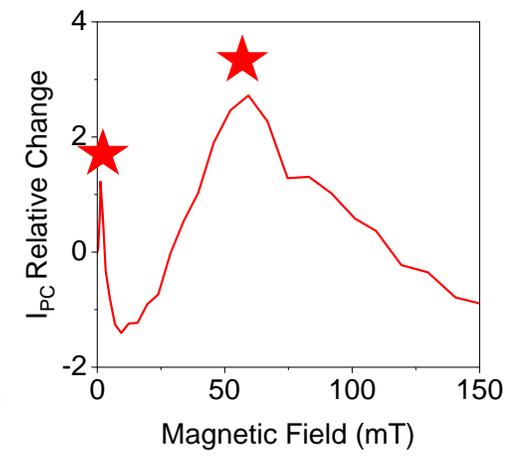
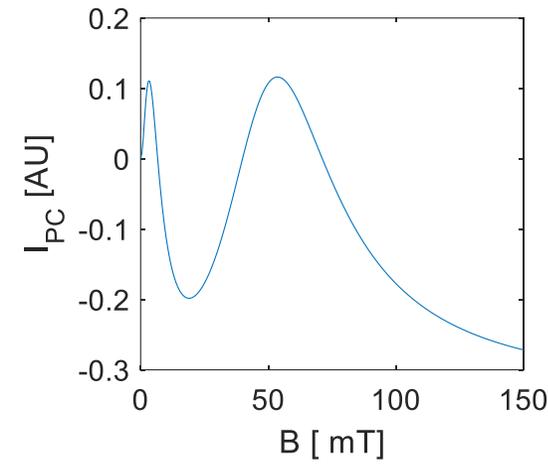
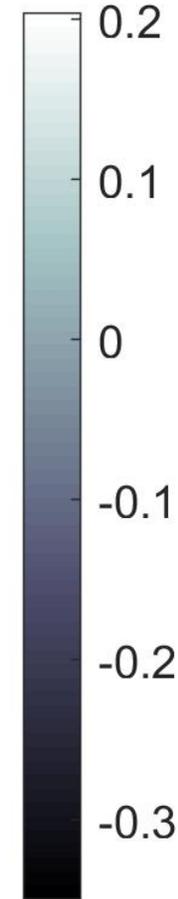
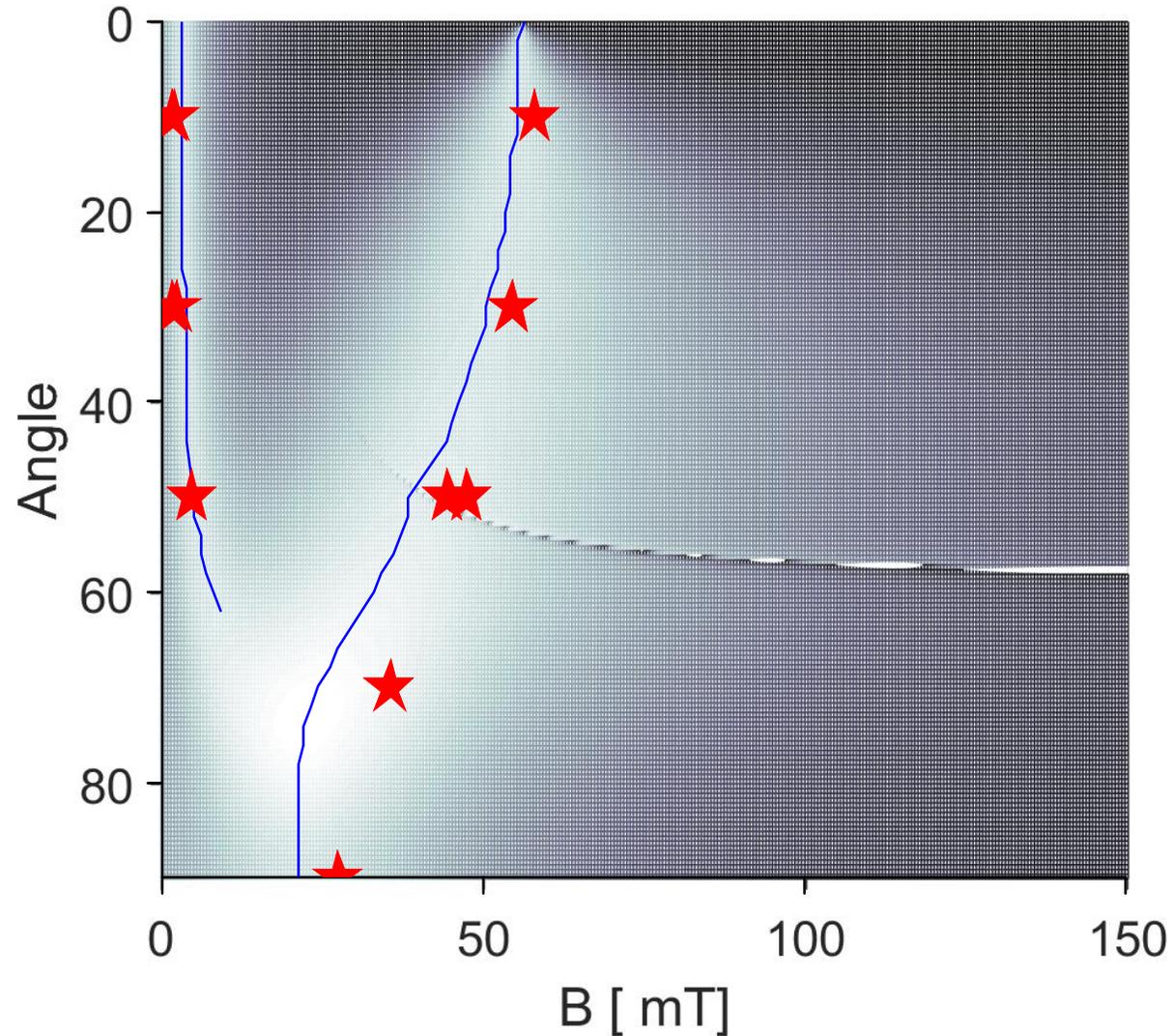


# $I_{PC}(B)$ Model for two angles

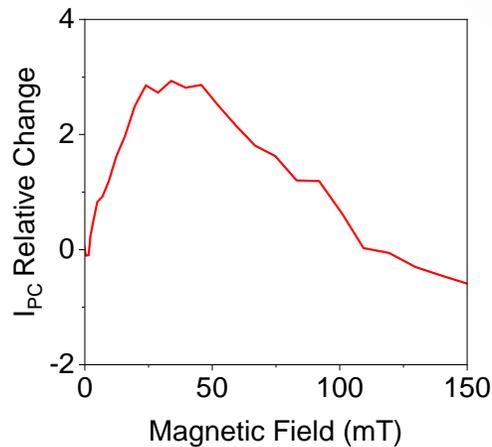
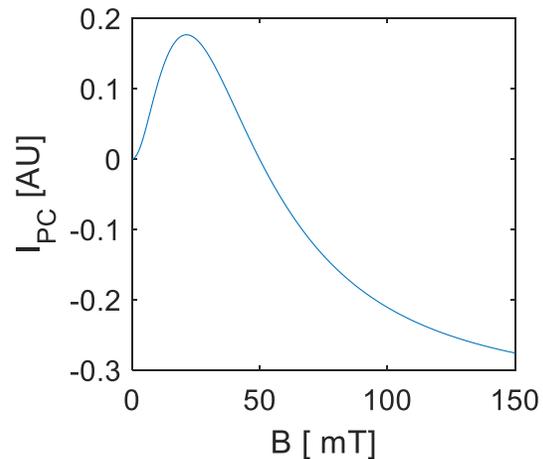
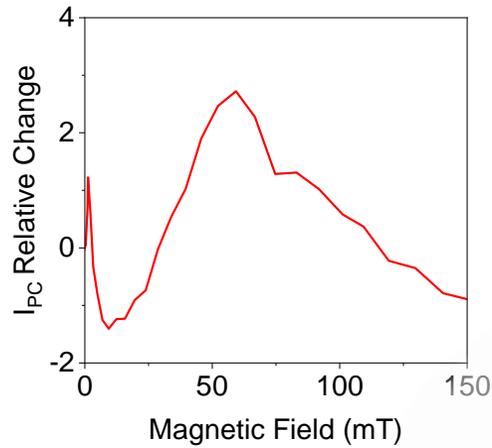
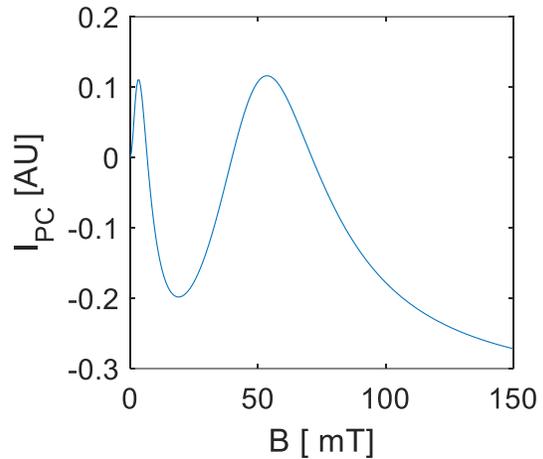
B-field direction



# Model and data correlation



# Conclusions:



Magnetic-field effects on photocurrent can be explained by triplet population manipulation in diF TES ADT

Extra information:

- Simple measurement of triplet state impact on device photocurrent
- Orientation of the molecule matters

**Opportunities to work at NIST!**  
Post doc: NRC Fellowship (\$71K/year) [tinyurl.com/yyz8kt22](https://tinyurl.com/yyz8kt22)  
Undergraduate fellowship: SURF [nist.gov/surf](https://nist.gov/surf)

 [Emily.Bittle@nist.gov](mailto:Emily.Bittle@nist.gov)

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