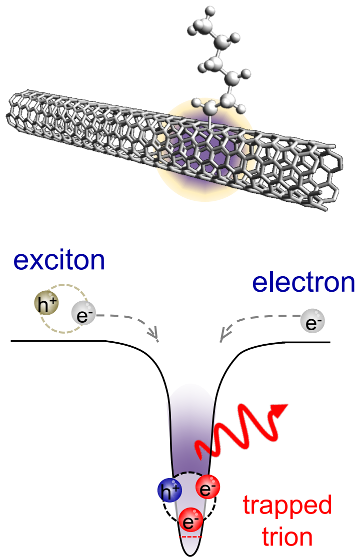
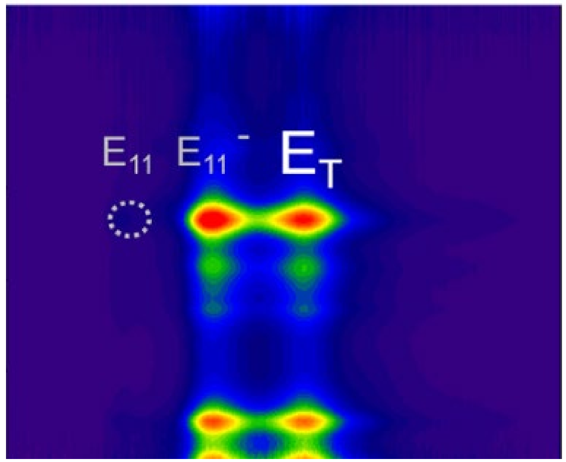
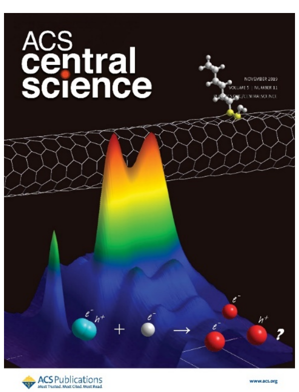
YuHuang Wang, University of Maryland (CHE-1904488-renewal, CHE-1507974-completed; PHY-1839165 RAISE)

Chemical defects stabilize and brighten trions





Left: A functional group on a single-walled carbon nanotube creates a chemical defect that traps and stabilizes a trion.
Right: Trions fluoresce brightly (at E_T) relative to the carbon nanotube host (E_{11}) and defect-trapped excitons (E_{11}^-).



References
"Probing trions at chemically tailored trapping defects." Kwon, H.J.; Kim, M.; Nutz, M; Hartmann, N.F.; Perrin, V.; Meany, B.; Hofmann, M. S.; Clark, C.W.; Htoon, H.; Doorn, S.K.; Högele, A.; Wang, Y.H. *ACS Central Science* **2019**, 5, 11, 1786-1794.
See also: Neil Savage, "Chemically tweaked nanotubes trap trions." *Chemical & Engineering News* **2019**, November 11, page 9.

Key Outcome: Trions are tri-carrier quasi-particles with rich physics but they are unstable. Trapping at defect sites on carbon nanotubes stabilizes trions, giving rise to extraordinarily bright photoluminescence in the shortwave infrared.

Impact & Benefits: This work makes trions synthetically accessible and may broadly impact their applications in bioimaging, chemical sensing, energy harvesting, and light emitting in the shortwave infrared.

Background: Trions—charged excitons that are reminiscent of hydrogen and positronium ions—have been intensively studied for energy harvesting, light-emitting diodes, lasing, and quantum computing applications because of their inherent connection with electron spin and dark excitons. However, these quasi-particles are typically present as a minority species at room temperature making it difficult for quantitative experimental measurements. Supported in part by NSF's chemistry and RAISE (through PHYS) programs, Wang and his students at the University of Maryland have collaborated with colleagues from Ludwig-Maximilians-Universitat München, Gemrany and Los Alamos National Laboratory to address this challenge and found it is possible to efficiently generate and stabilize trions at sp^3 defect sites that are synthetically introduced into the sp^2 lattice of semiconducting carbon nanotube hosts.