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Extraordinary Excitons in Phosphorene

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Phosphorene¹ is a recently developed 2D material that has attracted tremendous attention owing to its unique anisotropic manner², layer-dependent direct band gaps^{3, 4}, and quasi-one-dimensional (1D) excitonic nature⁵, which are all in drastic contrast with the properties of other 2D materials, such as graphene and transition metal dichalcogenide (TMD) semiconductors. Monolayer phosphorene has been of particular interest in exploring technological applications and investigating fundamental phenomena, such as 2D quantum confinement and many-body interactions⁶.

Here, we observed extraordinary excitons in phosphorene⁴. Also, large trion (charged exciton) binding energy has been observed in phosphorene⁵. In addition, we successfully engineered the luminescent states in phosphorene, which leads to the localization of excitons to quasi-0D states and triggers photon emissions at new wavelengths^{7, 8}.

References

- (1) L. Li, Y. Yu, G. J. Ye, Q. Ge, X. Ou, H. Wu, D. Feng, X. H. Chen, Y. Zhang. "Black phosphorus field-effect transistors" *Nat Nanotechnol*, **2014**, 9, 372-377.
- (2) F. Xia, H. Wang, Y. Jia. "Rediscovering black phosphorus as an anisotropic layered material for optoelectronics and electronics" *Nat Commun*, **2014**, 5, 10.1038/ncomms5458.
- (3) R. Xu, J. Yang, Y. Zhu, H. Yan, J. Pei, Y. W. Myint, S. Zhang, Y. Lu. "Layer-dependent surface potential of phosphorene and anisotropic/layer-dependent charge transfer in phosphorene-gold hybrid systems" *Nanoscale*, **2015**, 10.1039/C5NR04366B.
- (4) S. Zhang, J. Yang, R. Xu, F. Wang, W. Li, M. Ghufuran, Y.-W. Zhang, Z. Yu, G. Zhang, Q. Qin, Y. Lu. "Extraordinary photoluminescence and strong temperature/angle-dependent raman responses in few-layer phosphorene" *ACS Nano*, **2014**, 8, 9590-9596.
- (5) R. Xu, S. Zhang, F. Wang, J. Yang, Z. Wang, J. Pei, Y. W. Myint, B. Xing, Z. Yu, L. Fu, Q. Qin, Y. Lu. "Extraordinarily bound quasi-one-dimensional trions in two-dimensional phosphorene atomic semiconductors" *ACS Nano*, **2015**, doi:10.1021/acsnano.5b06193.
- (6) J. Yang, R. Xu, J. Pei, Y. W. Myint, F. Wang, Z. Wang, S. Zhang, Z. Yu, Y. Lu. "Optical tuning of exciton and trion emissions in monolayer phosphorene" *Light Sci Appl*, **2015**, 4, e312.
- (7) R. Xu, J. Yang, Y. W. Myint, J. Pei, H. Yan, F. Wang, Y. Lu. "Exciton brightening in monolayer phosphorene via dimensionality modification" *Adv Mater*, **2016**, n/a-n/a.
- (8) J. Pei, X. Gai, J. Yang, X. Wang, Z. Yu, D.-Y. Choi, B. Luther-Davies, Y. Lu. "Producing air-stable monolayers of phosphorene and their defect engineering" *Nat Commun*, **2016**, 7.