New insulating and superconducting states in metal-organic frameworks and covalent organic frameworks

H. L. Nourse[a], R. H. McKenzie[b] and B. J. Powell[b]

[a] *Quantum Information Science and Technology Unit, Okinawa Institute of Science and Technology Graduate University, Onna-son, Okinawa 904-0495, Japan.*

[b] *School of Mathematics and Physics, The University of Queensland, Qld 4072, Australia.*

Many metal-organic frameworks (MOFs) and covalent organic frameworks (COFs) have decorated lattices, with intricate structural motifs within the unit cell. We consider a simple example of a decorated lattice, the decorated honeycomb (or star) lattice. We show that the interplay of decoration with strong electronic correlations leads to a menagerie of new insulating states [1-3]. Some of these can be understood by generalizing the idea of the dimer-Mott-insulator familiar from BEDT-TTF and $Pd(dmit)_2$ salts [1]. Other insulating states lead to new extensions of the Mott insulator concept [2,3].

We show that highly unconventional superconductivity occurs on doping away from these insulating states [4]. Most surprisingly, we find f-wave singlet superconductivity. On undecorated lattices the antisymmetrisation of fermionic wavefunctions requires that f-wave superconductors are triplets. We explain how decorated lattice structures allow us to evade this requirement while retaining an antisymmetric wavefunction [4].

Finally, the generalization to other decorated lattices and the connection to specific MOFs and COFs will be discussed [5]. We will ask why most MOFs and COFs are insulators and what can be done to find more metals and superconductors.

[1] J. Black and V. White, *J. Irrep. Res.* **100**, 187 (2002).

[2] H. L. Nourse, R. H. McKenzie, and B. J. Powell, *Phys. Rev. B* **103**, L081114 (2021).

[3] H. L. Nourse, R. H. McKenzie, and B. J. Powell, *Phys. Rev. B* **104**, 075104 (2021).

[4] H. L. Nourse, R. H. McKenzie, and B. J. Powell, *Phys. Rev. B* **105**, 205119 (2022).

[5] J. Merino, M. Fernandez Lopez, and B. J. Powell, *Phys. Rev. B* **103**, 094517 (2021).

[6] R. Murase, T. D. Hudson, T. Aldershof, K. Nguyen, J. G. Gluschke, E. P. Kenny, X. Zhou, T. Wang, M. van Koeverden, B. J. Powell, A. P. Micolich, B. F. Abrahams and D. M. D'Alessandro, *J. Am. Chem. Soc.* **144**, 13242 (2022).