Nonperturbative momentum dependency in diagrammatic calculations

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The study of disorder in Condensed Matter Physics is as old as the field itself. Disorder can supress desirable material properties such as the conductivity but it can play a fundamental role in quantum phase transitions and can even be shown to enhance superconductivity [1]. The requirement of a realistic quantum description of disorder led to the development of diagrammatic techniques which are able to deal with disorder in a controlled way [2,3] by expanding the disorder averaged Green's function in powers of the disorder strength or the impurity concentration. Several approximation schemes may be employed in order to resum an infinite subseries of diagrams, such as the self-consistent T-matrix approximation and the Born approximation. While nonperturbative, these approaches typically fail to capture any momentum dependency of the Green's function not coming from the dispersion relation. Here, we present a nonperturbative method to capture the momentum dependency of the disorder in the disorder-averaged Green's function, effectively summing a larger subset of diagrams. We use KITE [4,5] to apply this method to several 2D systems such as the square lattice subject to Anderson disorder, graphene with vacancies and $SrRuO_3$.

REFERENCES

[1] M. Leroux, V. Mishra, J. P. C. Ruff, H. Claus, M. P. Smylie, C. Opagiste, P. Rodière, A. Kayani, G. D. Gu, J. M. Tranquada, W.-K. Kwok, Z. Islam, and U. Welp, Proc. Natl. Acad. Sci. (USA) 116(22) (2018) 10691

[2] Altshuler, B. L., Khmel'nitzkii, D., Larkin, A. I., and Lee, P. A., Physical Review B 22(11) (1980) 5142

[3] Hikami, S., Larkin, A. I., and Nagaoka, Y., Progresses of Theoretical Physics, 63(2) (1980) 707-710

[4] Ferreira, A. and Mucciolo, E. R. (2015). Physical Review Letters, 115(10) 106601

[5] João, S. M., Anđelković, M., Covaci, L., Rappoport, T. G., Lopes, J. M. V. P., and Ferreira, A. Royal Society Open Science, 7(2) (2020) 191809.

FIGURES

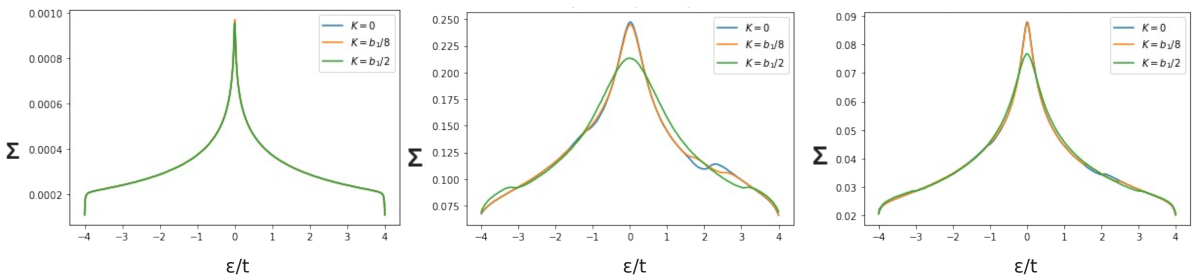

Figure 1: Self-energy of the square lattice as a function of energy for several values of the electron momentum and Anderson disorder strength. Diagrammatically, momentum-dependent diagrams should become relevant for higher values of the disorder strength, as is seen here.