Canonical Duality and Triality: Unified Understanding Complex Systems and NP-hard Problems

David Yang Gao

University of Ballarat and
Australian National University, Canberra, Australia
d.gao@ballarat.edu.au, david.gao@anu.edu.au

Keywords. Global optimization; NP-hard problems; canonical duality.

Canonical duality is a potentially powerful theory, which can be used to model complex phenomena within a unified framework. The associated triality theory reveals an interesting multi-scale duality pattern in complex systems, which can be used to identify both global and local extrema and to design efficient algorithms for solving a wide class of challenging problems in global optimization and computational science.

Beginning with some fundamental principles and basic concepts in mathematical physics, the speaker will show how the canonical duality theory be naturally and correctly developed and why a unified solution form can be obtained for totally different problems in nonconvex/discrete systems. Then he will explain the common misunderstandings on this theory, what is the open problem left in triality theory, and how this open problem is solved. Based on this canonical duality/trialtiy theory, he will first show how the NP-complete quadratic integer programming problem can be identically reformed as a continuous unconstrained Lipschitzian global optimization problem such that it can be solved via deterministic methods, then he explain the fundamental reason that leads to challenging problems in different fields, including NP-hard problems in global optimization and the paradox of Buridan's donkey in decision sciences. By using nonlinear perturbation methods in physics, he will present a new powerful primal-dual algorithm for solving general challenging problems in global optimization. Applications will be illustrated by certain well-known NP-Hard problems. He will show that in complex systems, the global minimizer may not be the best solution. Finally, some open problems and challenges will be addressed.

This talk should bring some fundamentally new insights into complex systems theory, global optimization and computational science.

References

[1] Gao D. Y. (2009) Canonical duality theory: Unified understanding and generalized solution for global optimization problems. *Computers & Chemical Engineering*, Vol. 33, pp. 1964–1972. doi:10.1016/j.compchemeng.2009.06.009.

[2] Wu C., Li C., Gao D. Y. (2012) Canonical primal-dual method for solving nonconvex minimization problems, *http://arxiv.org/abs/1212.6492*