A Deterministic Algorithm for Phasing Using Triplet and Quartet Invariants

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Traditional approaches to the crystallographic phase problem minimize merit functions of structural geometry to determine the missing phases [1]. To accurately model the diffraction physics, these merit functions are highly nonlinear and multimodal. As a result, phasing requires the solution of challenging global optimization problems. Trial-and-error, in combination with local search, has been used extensively to solve these optimization problems but is a tedious and difficult process, even for small molecules.

For centric structures, the phase problem has recently been approached via combinatorial optimization techniques that are guaranteed to find a global optimum of a minimal principle formulation of the phase problem [2]. This methodology leaves no ambiguity regarding the correctness of the phases thus derived.

We study how the addition of quartet invariants to the phasing model affects the resolution limits of the previous work [2], which only included triplet invariants. Phasing is accomplished with a polynomial-time binary Gaussian elimination algorithm. For a collection of structures, our methodology leads to considerably improved solutions at lower resolutions.

[1] Debaerdemaeker T., Woolfson M. M., *Acta Crystallographica A*, 1983, **39**,193-196. [2] Vaia A., Sahinidis N. V., *Acta Crystallographica A*, 2003, **59**(5), 452-458.

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