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THE DISCRETE ELEMENT METHOD: ADVANCES AND FUNDAMENTAL ISSUES

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ABSTRACT

Many physical problems, such as granular systems, exhibit a discrete nature, and traditional continuum based modelling techniques may not provide an adequate and/or effective description. The most challenging modelling aspect stems from the fact that many discrete (granular) systems may be influenced by the simultaneous presence of solid, fluid and/or other secondary (granular) flow phases. Discrete particle based techniques have emerged as very powerful numerical modelling tools and play an increasingly important role in the simulation of many industrial problems, including geo-mechanical, chemical engineering, nuclear engineering, and pharmaceuticals. The underlying methodology has the potential to offer a more reliable modelling strategy in multi-scale simulations for many applications and is also applicable to nano-techniques. When coupled with other physical phases, such methods can provide a unique modelling tool for bio- and nano-medical applications.

The discrete element method, as one of particle based techniques, has been extensively developed over the last decade and established as a powerful computational modelling tool for many scientific and engineering problems exhibiting discrete/discontinuous phenomena. Recent advances include the coupling of discrete particles with fluid flows for the modelling of particle transport problems [1,2], and the development of a novel discrete thermal element approach for the simulation of heat transfer in particulate systems [3]. These new developments have significantly extended the applicability of the discrete modelling methodology to even broader practical problems.

Although significant progress has been made in the development of the discrete element method, there are a number of fundamental issues that need to be addressed and a significant degree of fundamental research is urgently required to establish the current methodology on a more mathematically sound foundation. A crucial issue is the upscaling of a discrete model, which is of significant theoretical and practical importance, and is fundamentally related to the mathematical description of the dynamic evolution of particle systems. To tackle these issues, further developments/applications of novel mathematical approaches in combination with particle/granular mechanics and multi-scale modelling appear to be essential. They represent a number of leading edge research topics and their solution will have profound theoretical, computational and

practical impact. A preliminary work on the issue is reported in [4], in which a set of similarity principles governing the equivalence between both physical and computational models is proposed.

In addition, the current discrete element modelling is of a deterministic nature whereby all the aspects of a discrete element model are assumed to be fully determined *a priori*. A large degree of uncertainty and randomness is however present in real applications. Therefore it is of both theoretical and practical importance to incorporate various types of randomness with effective stochastic descriptions into the current discrete element methodology.

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