Abstract Submitted
for the MAR12 Meeting of
The American Physical Society

**Discrete Calculus as a Bridge between Scales** ERIC DEGIULI, Dept. Mathematics, UBC, JIM MCELWAINE, DAMTP, University of Cambridge — Understanding how continuum descriptions of disordered media emerge from the microscopic scale is a fundamental challenge in condensed matter physics. In many systems, it is necessary to coarse-grain balance equations at the microscopic scale to obtain macroscopic equations. We report development of an exact, discrete calculus, which allows identification of discrete microscopic equations with their continuum equivalent [1]. This allows the application of powerful techniques of calculus, such as the Helmholtz decomposition, the Divergence Theorem, and Stokes' Theorem. We illustrate our results with granular materials. In particular, we show how Newton's laws for a single grain reproduce their continuum equivalent in the calculus. This allows introduction of a discrete Airy stress function, exactly as in the continuum. As an application of the formalism, we show how these results give the natural mean-field variation of discrete quantities, in agreement with numerical simulations. The discrete calculus thus acts as a bridge between discrete microscale quantities and continuous macroscale quantities.

[1] E. DeGiuli & J. McElwaine, PRE 2011. doi: 10.1103/PhysRevE.84.041310

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Date submitted: 16 Nov 2011 Electronic form version 1.4