Extending the Applicability of Non-Contact Modulation Calorimetry through Modeling

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Non-contact modulation calorimetry has been employed with electromagnetic levitation, particularly in reduced gravity, for the measurement of specific heat of solid and liquid metals, and for the measurement of thermal conductivity of high-melting solid metals. For the past 25 years, since the pioneering work of Fecht and Johnson, a two-reservoir model has proven sufficient for these measurements, so long as the modulation frequency is well-matched to the actual properties of the material. However, particularly for measurement of thermal conductivity in liquids in the presence of fluid flow, a more detailed model is needed. We present the results of a finite-element magnetohydrodynamic model that captures the real distribution of temperature, input power, thermal conduction, and convective heat transfer. The results of this model provide quantitative prediction of the range of parameters over which thermal conductivity measurements are feasible, and also quantification of uncertainties in the measurement of both thermal conductivity and specific heat.