Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Thermophoresis of a spherical particle: Modeling through moment-based, macroscopic transport equations[1] JUAN C. PADRINO, JAMES SPRITTLES, DUNCAN LOCKERBY, University of Warwick — Thermophoresis refers to the forces on and motions of objects caused by temperature gradients when these objects are exposed to rarefied gases. This phenomenon can occur when the ratio of the gas mean free path to the characteristic physical length scale (Knudsen number) is not negligible. In this work, we obtain the thermophoretic force on a rigid, heat-conducting spherical particle immersed in a rarefied gas resulting from a uniform temperature gradient imposed far from the sphere. To this end, we model the gas dynamics using the steady, linearized version of the so-called regularized 13-moment equations (R13). This set of equations, derived from the Boltzmann equation using the moment method, provides closures to the mass, momentum, and energy conservation laws in the form of constitutive, transport equations for the stress and heat flux that extends the Navier-Stokes-Fourier model to include rarefaction effects. Integration of the pressure and stress on the surface of the sphere leads to the net force as a function of the Knudsen number, dimensionless temperature gradient, and particle-to-gas thermal conductivity ratio. Results from this expression are compared with predictions from other moment-based models as well as from kinetic models.

[1]Supported in the UK by the Engineering and Physical Sciences Research Council (EP/N016602/1)

Juan C. Padrino
University of Warwick

Date submitted: 01 Aug 2017 Electronic form version 1.4