Sometimes, We Really Want the Right Answer

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By design, most engineering processes are only weakly sensitive to their inputs, including thermophysical property data. On rare occasions, highly accurate thermophysical property data are needed, for example, to tightly control a process, to optimize efficiency, to meter a high value product, or to determine the thermodynamic temperature. Where can we get such highly accurate data? In the 21st century, the most accurate thermophysical property data for any gas is generated by quantum-mechanical calculations of the properties of helium, even at densities well above the dilute gas regime. When we use the calculated properties of helium as standards, we can understand and/or calibrate laboratory apparatus in remarkable detail. Then, carefully selected ratio measurements determine accurate working standards for temperature, equation-of-state, dielectric constant, thermal conductivity, viscosity, speed of sound, and the flow of gases. A chain of ratio measurement leads from helium to argon and ultimately to industrially important gases such as moist air and the reactive gases used to process semiconductors. Ratio measurements can also refine the parameters in model interatomic and intermolecular potentials. Then, model potentials can be used to accurately predict thermophysical properties of gases at high temperatures and pressures, where accurate measurements are difficult