Necessary Details for the Helium Equation of State at Low Temperature

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Development of input data for a helium equation of state is complicated by several non-obvious factors that can lead to errors if not handled properly. The first factor is the role of helium vapor-pressure curves in defining the International Temperature Scale of 1990 (ITS-90); this should constrain the vapor pressure of an EOS that uses ITS-90 temperatures. The second is the different temperature scales used in the past for low-temperature helium, meaning that typical conversion routines for scales that did not extend to liquid helium temperatures (ITS-48, IPTS-68, etc.) cannot be used. Third, many reported "density" data were actually measurements of the static dielectric constant or the refractive index that were converted to densities using information that is now obsolete; if the original work was sufficiently well documented, these densities can be corrected based on modern *ab initio* calculations of helium's atomic polarizability and its second dielectric and refractivity virial coefficients. Implications are discussed for future refitting of the current (unpublished) reference equation of state for helium in the REFPROP database, and for a future reference EOS for the helium-3 isotope.