Final Experimental Results for the Virial Coefficients of Argon and Neon and their Utilization in Gas Metrology

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Recent interest and advances in gas metrology, for instance in the field of optical pressure measurement but also in gas thermometry, were initiated by the redefinition of the international system of units in 2019 and supported by large-scale projects like "Quantum Pascal" and "Real-K". Within their frame, major efforts were undertaken to determine the different gas properties required for these methods. This presentation focuses on the final results of the last years that were obtained by automated combined Burnett-type expansion and Dielectric-Constant Gas Thermometry (DCGT) experiments, namely molar polarizability as well as dielectric and density virial coefficients [1]. Argon is of key interest in this regard since its measuring effect is eight times higher than helium which is typically used so far due to its easy computability. Neon only offers a measuring effect twice as high but was particularly important for theoreticians in the projects to learn to handle atoms with more electrons. Previously reported results for argon were refined by extensive calibrations of the apparatus constant with helium at the individual measuring temperatures of 253 K, 273 K, 296 K and 303 K [2]. Furthermore, novel and complex working equations for the derivation of third virial coefficients from expansion setups with two temperature zones were developed and applied. Finally, these results will be put into perspective by a short overview of the overall improvements on thermophysical and dielectric properties of argon that were achieved within these projects. Essentially, the refractive index and required virial coefficients are now available for a broad temperature and frequency range with uncertainties that in principle allow the determination of pressure by optical experiments with uncertainties on the order of 10 ppm up to around 100 kPa.

Acknowledgments

These projects 18SIB04 Quantum Pascal and 18SIB02 Real-K have received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

References

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