Polarizability of Helium, Neon, and Argon - New Perspectives for Gas Metrology

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With dielectric-constant gas thermometry, the molar polarizabilities of helium, neon and argon have been determined with relative standard uncertainties of a few parts per million. A series of isotherms, measured with the three noble gases and two different experimental setups, led to this unprecedented level of uncertainty. This data is crucial for scientists in the field of gas metrology, working on pressure and temperature standards etc. Furthermore, with these new benchmark values for neon and argon, theoretical calculations, today about three orders of magnitude larger in uncertainty, can be checked and improved. The electric dipole polarizability, describing the response of an atom or molecule to an external electric field, is a fundamental property of an atomic or molecular system. Therefore, reliable data is indispensable. In the last decades, large progress was achieved with *ab initio* calculations for the polarizability of helium, where relativistic and quantum-electro-dynamical corrections can be treated. The level of uncertainty of 0.1 parts per million [1] is unachievable via experimental techniques, even though the present work reduces the experimental uncertainty by almost a factor of 5 compared to the best previous work [2]. On the other hand, *ab initio* calculations for larger rare-gas atoms like neon and argon reveal much larger uncertainties on the tenth of a percent level due to the more complex electronic structure. Thus, these calculations must be checked by comparison with reliable experimental data, which serves not only as reference value for one special atom, but also as a benchmark value to prove the efficiency of equally valid calculation techniques. Furthermore, the present results are a step towards primary gas thermometry [3] or a pressure standard [4] with helium, neon and argon [5]. They will allow an accurate density measurement via an electrical or optical detection method.

References:

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