Comparison Between Experimental Determinations and Theoretical Modelling of Speed of Sound in Humid Air

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Using an acoustic interferometer set-up in a large-volume hemi-anechoic chamber, we have measured the speed of sound in humid air near ambient pressure p while the main influence parameters temperature T, relative humidity h_r, carbon dioxide concentration x_{CO2} and acoustic frequency f where varied in the ranges 284 K < T < 301 K, 30 % < h_r < 60 %, 400 ppm < x_{CO2} < 700 ppm, and 5 kHz < f < 20 kHz, respectively.

We have compared a subset of these experimental determinations with those obtained using a stainless steel spherical acoustic resonator whose internal volume was flushed at a steady flow rate with air sampled from the chamber. The results from the two experiments were found to be consistent within their combined relative uncertainty on the order of 140 ppm.

The experimental results were used to support the assumption that the most complete model [A. J. Zuckerwar, *Handbook of the Speed of Sound in Real Gases – Vol. III Speed of Sound in Air* – Academic Press 2002] available for the prediction of the speed of sound in humid air $u(p, T, h_r, f)$ could be revised and updated to significantly reduce its uncertainty. This update considered the most accurate thermodynamic information available for the properties of the constituents of dry air, water vapor, and their mixture interaction, including heat capacities, virial coefficients and relaxation parameters.

The positive outcome of the comparisons between experimental results and those predicted by the updated theoretical model indicate that acoustic thermometry in humid air may be realized to be accurate at the level of 0.05 K, with promising perspectives for its practical application in dimensional measurements, temperature and acoustic metrology, and atmospheric physics.