DEVELOPMENT OF A COLD-ATOM VACUUM STANDARD (CAVS)

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NIST is embarking on a program to create a cold-atom vacuum standard (CAVS), that will be both a primary standard and absolute sensor of vacuum for pressures below 10-5 Pa, covering the entire ultra-high vacuum range (UHV), and into the extreme-high vacuum (XHV) range (<10-10 Pa). To date, there are no primary standards in this pressure regime, even though UHV is critical to advanced research and manufacturing. The CAVS is based on the loss-rate of ultra-cold sensor atoms (< 1 mK) from a shallow magnetic trap (E/kB< 1 mK). Collisions between the trapped sensor atoms and the ambient (300 K) background gas in the vacuum result in atom loss from the trap. The loss-rate is thus related to background density in the vacuum and the loss-rate coefficient, or collision cross section, between the background gas and sensor atom. The loss-rate coefficient is a fundamental atomic property and can be determined theoretically from ab initio quantum calculations for the Li + H2 system. This calculation is presently underway at NIST. Experimentally, we are studying all other sources of atom loss that can possibly contribute to the loss rate, and we are determining collision cross sections and relative sensitivity factors so that the CAVS can be used with many species of gas. An important part of this project is to develop a portable, chip scale version of the CAVS. Once this deployable technology is developed, we anticipate that other practical metrology tools based on cold atoms will follow. This presentation will cover the physics of the CAVS and the most recent results. Time permitting, we will also have some discussion of another NIST effort to determine the gas absorption and outgassing properties of novel 3D-printed materials for gas storage and sensing.