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Absolute pressure standard using cold atoms

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Particle detection in high and ultra-high vacuum environments below 10^{-6} torr is essential for beam flux measurements and ambient pressure determinations. Electron impact ionization and subsequent detection of the ions is, at present, the most widespread and sensitive method and it constitutes the functional basis for ionization vacuum gauges. These gauges suffer from the limitation that they lose their calibration when the ion production or collection efficiencies change because the sensor electrodes change position and the internal electric fields are altered or when the gain of the ion current multiplier is modified due to surface contamination or degradation. By contrast, a stationary or slowly moving atom, such as can be prepared by laser cooling, is an ideal particle flux sensor. In brief, the passage of a particle through the collision cross section of the sensor atom is detected by the momentum transferred to the quasi-stationary sensor atom. The incident particle flux is determined from the measured single-particle collision rate divided by the total cross section. The latter quantity can be computed from knowledge of the interaction potentials and the former is a measurement of time. The main advantage of this detection mechanism is that it is not subject to sensor degradation or calibration drift since the sensor atoms are always the same and the interaction between the sensor atom and the detected particle is an immutable law of nature. These features and the direct link between particle flux and time makes this method a unique candidate for the realization of a primary pressure standard at and below 10^{-6} torr.

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