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An optically-levitated, spinning-rotor vacuum gauge[1] CHARLES BLAKEMORE, DENZAL MARTIN, ALEXANDER FIEGUTH, AKIO KAWASAKI, NADAV PRIEL, ALEXANDER RIDER[2], GIORGIO GRATTA, Stanford University — Optical trapping and the systems created by optically trapped particles have applications ranging from manipulations of single cells to precision force sensing and searches for new physics. In this work, the authors demonstrate a novel metrological application wherein an optically trapped and rotating microsphere is used as a spinning-rotor vacuum gauge. Rotation is induced electrostatically, by applying torque to the permanent electric dipole moment found in some silica microspheres, and measured optically, by analyzing the light transmitted through the microsphere. The kinetic theory of gases relates the torsional drag on a spinning microsphere to the pressure of residual gas in the immediate vicinity of the microsphere, calibrated by measuring the rotor mass with electrostatic co-levitation, and assuming a spherical shape and uniform density. Two distinct techniques allow the measurement of torsional drag in both moderate and high vacuum conditions. At moderate vacuum, torsional drag is measured as a phase lag between the electrostatic driving field and the rotation of the microsphere. At high vacuum, the time constant of exponential decay when the microsphere is released from a driving field is also related directly to the torsional drag.

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