Cavity Polarization Mode Impedance Matching Spectroscopy

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Cavity enhanced gas analyzers have been used in many research areas, and are now finding their way into industrial applications. Here we present a new cavity enhanced spectroscopy technique named Cavity Polarization Mode Impedance Matching Spectroscopy (PIMS). Besides being a real-time readout and having high absorption sensitivity, PIMS also uses a low complexity, modulation-free setup, making it a promising candidate for both field-deployable and laboratory-based applications. PIMS belongs to a new family of techniques that measures gas absorption by probing the impedance matching condition (also known as coupling condition) of an optical cavity. It uses the intrinsic characteristic of a birefringent cavity with nondegenerate polarization modes to provide the desired impedance matching readout. Light in one polarization is used to probe the intra-cavity gas absorption. The orthogonally polarized light becomes a reference as it is not resonant with the cavity. A linear polarization analyzer is used to interfere these two polarization modes. The resulting interference signal is linearly proportional to the intra-cavity absorption. This analyzer also provides common-mode rejection of laser intensity noise, largely removing its influences on the absorption signal. We conducted a proof of concept experiment by using this PIMS spectrometer to measure a rovibrational overtone of CO_2 at 1572.992 nm. An absorption line was obtained which accurately reconstructed the predicted Voigt line profile. This proof of concept spectrometer exhibits a low noise equivalent absorption (NEA) that is already comparable to some existing cavity enhanced systems. As these results demonstrate, PIMS offers an elegant alternative architecture for cavity enhanced high sensitivity gas absorption measurements.