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Static magnetic Faraday rotation spectroscopy combined with a differential scheme for OH detection

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The hydroxyl (OH) radical plays a critical role in atmospheric chemistry due to its high reactivity with volatile organic compounds (VOCs) and other trace gaseous species. Because of its very short life time and very low concentration in the atmosphere, interference-free high sensitivity in-situ OH monitoring by laser spectroscopy represents a real challenge.

Faraday rotation spectroscopy (FRS) relies on the particular magneto-optic effect observed for paramagnetic species, which makes it capable of enhancing the detection sensitivity and mitigation of spectral interferences from diamagnetic species in the atmosphere. When an AC magnetic field is used, the Zeeman splitting of the molecular absorption line (and thus the magnetic circular birefringence) is modulated. This provides an “internal modulation” of the sample, which permits to suppress the external noise like interference fringes. An alternative FRS detection scheme is to use a static magnetic field (DC-field) associated with laser wavelength modulation to effectively modulate the Zeeman splitting of the absorption lines. In the DC field case, wavelength modulation of the laser frequency can provide excellent performance compared to most of the sensing systems based on direct absorption and wavelength modulation spectroscopy.

The dimension of the DC solenoid is not limited by the resonant frequency of the RLC circuit, which makes large dimension solenoid coil achievable and the absorption base length could be further increased. By employing a combination of the environmental photochemical reactor or smog chamber with multipass absorption cell, one can lower the minimum detection limit for high accuracy atmospheric chemistry studies. In this paper, we report on the development of a DC field based FRS in conjunction with a balanced detection scheme for OH radical detection at 2.8 μm and the construction of OH chemistry research platform which combined a large dimension superconducting magnetic coil with the multipass cell and photochemical reactor chamber for real time in-situ measurement of OH radical concentration in the chamber.