Integrating cavities and ultra-sensitive absorption spectroscopy

Edward Strauss Fry

Texas A&M University, 4242 TAMU, College Station 77843, USA

Spectroscopy using an integrating cavity with diffuse reflecting walls is a highly sensitive technique for weak absorption measurements. Since the diffuse reflecting walls of the cavity produce an isotropic illumination of the sample, absorption measurements are not affected by scattering in the sample. Due to multiple reflections of the light from the cavity walls, the light makes many transits through the sample, i.e. the effective path length through the sample far exceeds the dimensions of the sample; the result is a high sensitivity to very weak absorption. We have used this approach to measure the optical absorption of pure water and have just recently obtained the first reliable measurements down to 250 nm.

Another approach to high sensitivity absorption spectroscopy is cavity ring down spectroscopy (CRDS), a very different but well-known technique. It also provides a very long effective path length through the sample and is consequently an extremely sensitive technique for weak absorption measurements. But, since it cannot distinguish scattering from absorption, this powerful technique is only useful when scattering is negligible.

However, combining these two absorption spectroscopy techniques (integrating cavity and CRDS) would provide an extremely powerful and useful new technology - Integrating Cavity Ring-Down Spectroscopy (ICRDS). But, ICRDS has not previously been exploited because the diffuse reflectivity of all known materials was not high enough to do ring-down spectroscopy. Our newly developed diffuse reflecting material does have the required high diffuse reflectivity (e.g. 0.9992 at 532 nm) and is opening new research vistas by providing very sensitive and accurate direct spectral absorption measurements of both a sample and any particulates suspended in it while being unaffected by the scattering in the sample. An important example would be the capability to measure (for the first time) the very weak spectral absorption in highly scattering biological samples.