Cavity Ringdown Spectroscopy of Single Aerosol Particles

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Light scattering and absorption is widely used to probe the properties of dispersed colloidal particles (e.g. aerosol), providing information on size, shape and composition. Indeed, optical extinction by aerosols plays a key role in atmospheric optics, directly influencing the radiative balance of the atmosphere and impacting climate. Typically, light scattering is measured over a wide range of scattering angles and absorption can be inferred from a photoacoustic response. To determine optical cross-sections directly, cavity ringdown is widely used to probe an ensemble of particles. In many instances, rather than inferring the properties of particles from a single snapshot of optical extinction by a disperse ensemble, measurements of the evolving properties of a single particle are desirable. For example, to constrain and improve model predictions of light extinction by atmospheric aerosol, new tools should provide refined information on the dependence of light extinction on relative humidity, particle composition and heterogeneous aging, requiring time-dependent measurements. We will present a new technique using a combination of a Bessel beam to manipulate individual particles (200 to >3000 nm radius) and cavity ringdown spectroscopy for ultrasensitive measurements of their optical cross-section. Particles are spatially separated along the propagation direction of a Bessel beam according to their size and refractive index and the interplay of the forces arising from Stokes drag and radiation pressure, referred to as optical chromatography. Once captured, a particle can be moved into an optical cavity formed by two highly reflective mirrors. The time constant for the ringdown in light coupled within the cavity is used to measure the optical cross-section of the individual particle with extremely high accuracy. Thus, an individual particle can be captured indefinitely and its change in optical cross-section measured with change in environmental conditions.