This project seeks to develop a prototype system for the analysis of single levitated micrometre-sized particles captured from an ambient aerosol. The system is designed to use Raman scattering to establish chemical information of the particle, whilst simultaneously recording spatial elastic light scattering data from which an assessment of particle size, shape, and physical structure may be achieved. This multi-parametric approach should provide a means of discriminating atmospheric particles whose toxicity is determined by morphology as well as chemical composition. Areas of application could include environmental monitoring, source apportionment, occupational air-quality investigation, and potentially as part of a strategy for bio-aerosol detection.

The prototype SPaRS comprises several distinct sub-systems: a particle charging unit to allow sufficient charging of particles down to micrometre-sizes for their entrainment and capture from a sample aerosol flow; an electrodynamic levitation chamber capable of holding the captured particle essentially stationary whilst measurements are recorded; a diode laser particle illumination system; a Raman scattering spectrometer; and a spatial light scattering acquisition sub-system. Integration of the sub-systems to complete a laboratory prototype is underway and the use of the system will continue under a DSTL funded studentship (Dalley).

**Raman Scattering Acquisition**

The Raman effect is an inherently weak phenomenon with scattering cross-sections typically several orders of magnitude lower than other phenomena such as fluorescence which can entirely swamp the signal. The Raman spectrometer system developed here uses a number of technologies and design features to maximize the signal and fulfill the other requirements of the project.

1. The use of a Near Infra-Red (NIR) laser diode emitting light at 785nm significantly reduces fluorescence background.
2. A holographic notch filter (HNF) is employed to remove the Rayleigh scattering from the signal prior to the spectrometer. An HNF has a high transmission of all wavelengths outside the ‘notch’ and a very high optical density inside the notch. Its other chief characteristic is that the filter edges are very sharp so in principle it is possible to look at Raman signals close to the wavelength of the laser.
3. A CCD detector with thermoelectric cooling down to -40°C (or higher if necessary) allows long exposure times without the detector saturation problems.
4. A back scattering configuration is in progress, as well as facilitating simultaneous Raman and Rayleigh scattering acquisitions, improves the signal-to-noise performance because the back-scatter Raman signal is stronger than at 90° which is the more usual configuration (5).

**Spatial Scattering**

The spatial distribution of light scattered by a particle, often called the scattering profile, is a complex function of the size, shape, structure and orientation of the particle, as well as of the properties of the illuminating radiation (wavelength, polarization state).

The authors have developed a number of techniques based on the acquisition and analysis of the forward scattering profile of single microparticles. The basic configuration is illustrated schematically below (fig 4); example scattering patterns are shown below. Preliminary research at UH [3] has demonstrated that individual airborne particles can be characterized or classified by analysis of these patterns.

**Particle Charging and Trapping**

Single particles drawn from the ambient air are held still in an electrodynamic balance (EDB) for analysis. To capture and hold them adequately, particles must be charged sufficiently to enable them to be trapped in the EDB’s electric field. The AC unipolar charger used in this instrument provides a very effective method of charging particles. Initially, the charged particles will be collected on a grounded plate, and then selected with a tunnel grid and launched through a hole in the top of the trap. Further work, possibly using electrostatic focusing should lead to more automated sampling.

**Preliminary Results**

Although the EDB is not yet integrated into the system, the Raman spectrometer has been tested with single particles of ammonium nitrate and ammonium sulphate recorded from a levitated particle. Both spectra were obtained from 3Hz exposures. Ammonium nitrate shows a strong line at 2053 cm⁻¹ corresponding to the NO₂ stretching mode reported by Musick et al [2]. The three lines identified in the ammonium sulphate spectrum correspond to those reported by Zhang and Chen (7), represented below (fig 10). The large signal present near the laser lines are most likely due to the background generated by the tunable laser. Experiments with sulphuric acid clearly merits the 820 nm line showing that sub-100 cm⁻¹ spectral lines are resolvable.

**Scenarios**

- System for multifunctional analysis of ambient aerosol.
- AC unipolar charger and Electrodynamic balance sub-system for capturing and trapping particles.
- Sub-system for capturing forward scattering for shape and size analysis.
- Raman spectrometer sub-system for chemical analysis generating fast results, increasing good sensitivity and fluorescence suppression.
- Integration of various components underway.
- Further development and use of the instrument will continue under a DSTL funded studentship (Dalley).