tirely in the excitons.

Because excitons have mass, the spontaneous appearance of coherence of the excitons at high density is closely related to the phenomenon of Bose-Einstein condensation (*11*). In essence, all of the particles are attracted to a single quantum state. Unlike atomic gases, however, an exciton gas can undergo Bose condensation at relatively high temperature. Although the experiments at the Ottawa were done at 2 K, all of the coherent effects can in principle be observed at much higher temperatures. Excitons in Cu_2O, like many tightly bound excitons, are stable and a strong source of luminescence at room temperature (*12*).

Five years ago, the only laboratory examples of spontaneous coherence of massive particles were liquid helium and superconductors, both of which are strongly interacting systems. In the past 2 years, however, two new systems of massive particles have been demonstrated to have spontaneous attraction to a single coherent state, each of which is weakly interacting: alkali gases and excitons. For this reason, much of the theory for alkali gases and excitons has been applied equally to both disciplines. The exciton gas, unlike the atomic gas, has a transient lifetime of only microseconds, but on the time scales of modern optical communication devices, which exceed gigahertz switching rates, that is a very long time.

The work on coherent propagation of excitons has provided a new kind of light source, namely, a beam that propagates as a wave with a wavelength of angstroms but carries photons with energy in the visible range. Only time and imagination can tell what new applications may arise from this novel effect.

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Airborne Particle Analysis for Climate Studies

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Particulates in Earth's troposphere and stratosphere are important in many scientific, medical, and technological respects: They control climate change to a high degree, strongly influence atmospheric chemistry, affect our health, and disturb technological processes like chip manufacturing. Despite the pressing need for detailed information, the properties of aerosols are still hard to measure and classify owing to their tremendous diversity in particle number density, size, shape, physical state, and chemical composition. Moreover, measurement of these properties is often complicated because certain components are highly volatile and cannot be collected and analyzed by ex situ methods. Here, the recent blossoming of mass spectrometric (MS) methods (see figure) for contact-free real-time analysis of individual aerosol particles opens a new large field of applications with as yet unexplored possibilities. The work by Noble and Prather reported in a recent issue of *Environmental Science and Technology* (*1*) is an impressive realization of such an approach, providing an accurate measurement of the particle's size before it is ionized for subsequent chemical analysis.

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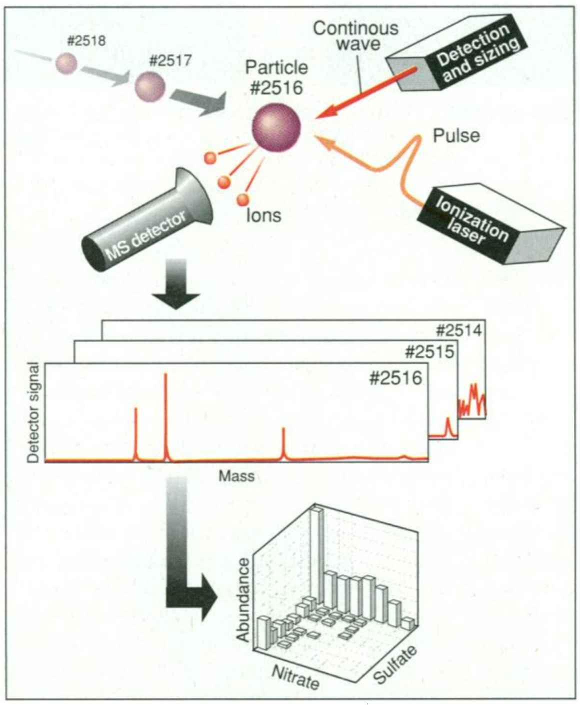

Resolved complexity and data reduction. An individual particle is detected by a continuous-wave laser and then ionized by a strong pulse from a second laser. The ions are mass analyzed, and information from hundreds or thousands of particles is grouped together to obtain the physical information. Spectra and abundance chart adapted from (*8*).

A glance at the mass spectra obtained from such methods reveals the wealth of information sometimes hidden in an individual micrometer-sized particle—indeed, too much to be easily digested when 10 such spectra come in every second. Some of them are easily classifiable, but many are different from all others. One might almost wonder what this flood of information is good for if it cannot be divided easily into broad categories.

It must be clear that in situ chemical analysis of individual airborne particles combined with accurate measurements of their physical properties will be indispensable in many fields of aerosol-related research if progress is to be made. We can perceive this with help of the following two examples. First, there is reason to believe that the anthropogenic component of tropospheric aerosols exerts a large negative driving force on Earth's climate that partly masks the positive forcing by anthropogenic greenhouse gases (*2*). However, in contrast to gaseous species, the radiative effects of aerosols up to now are modeled only very crudely because of the complex regional and temporal behavior of aerosol distributions, sizes, and chemical compositions, all of which govern the radiative interaction. This situation calls for closure experiments in which all the relevant parameters—radiation, gases, aerosols, and clouds—are determined simultaneously within the same air column. A set of such measurements at various geographical locations during all seasons in combination with sophisticated radiation codes will lead to the necessary parametrization of radiatively relevant aerosol properties. This systematic reduction of free parameters was impeded in the past because adequate methods for the analysis of the aerosols were missing. Ice particles obviously have radiative properties different from those of soot particles, but they cannot be distinguished simply by particle counting, nor can a collection of both species easily be brought to the ground for investigation in a laboratory.

Second, another and maybe even more compelling argument in favor of in situ aerosol MS is the necessity for process studies that go beyond an accurate characterization of a static situation. Polar stratospheric clouds serve as a good example. It is widely accepted that these clouds, which consist of micrometer-sized particles, are a prerequisite for the Antarctic ozone hole (*3*), as well as for the ozone loss in the Arctic, which seems to become stronger each year (*4*). Although the bulk of these cloud particles consists of only three species—sulfuric acid, nitric acid, and water—it is still a riddle how the particles freeze (*5*). Although the thermodynamics of aqueous H_2SO_4-HNO_3 droplets has been established within the last 3 years and the thermodynamics of the frozen hydrates has been known even longer, transitions between these phases are not well understood at all. Aerosol MS would help the understanding of these kinetic processes, in particular when combined with accurate size measurements, as in Noble and Prather's experiment, to test predicted but yet unproven composition-size correlations (*6*). Such instruments ought to be applied on a carrier that traverses the clouds on a quasi-Lagrangian flight path, that is, flying with the particles and observing their behavior as function of time.

A general caveat of the methods developed so far is that even identical particles can cause a scatter in spectroscopic signal intensity of 50% and more. This is a result of the unknown ionization efficiencies in the plasma of the pulsed laser focus. A grouping of large data sets for sufficiently identical particles can significantly reduce the uncertainties in concentrations, as has been described in the survey on aerosol MS by Johnston and Wexler (*7*). At the same time, general rules on how to construct an optimal particle grouping under field conditions are still missing.

To perform field experiments with these methods, in particular under hostile upper tropospheric or lower stratospheric conditions, is, of course, easier said than done. Not only is it difficult to find a carrier that is able to fly through stratospheric clouds in a quasi-Lagrangian manner, more importantly, instruments adapted to the prevailing temperature and pressure conditions do not yet exist. Furthermore, the requirement of light and compact instrumentation renders such measurements enormously ambitious. Nevertheless, effort is currently directed into this direction: Murphy and Thomson (*8*) have used a portable ground-based aerosol MS in the field, and further miniaturization is conceivable. Another approach is being taken by Mauersberger and Schreiner (*9*) especially for stratospheric purposes. They use a sophisticated particle lens system based on a development by McMurray and co-workers (*10*), which significantly increases the particle-to-air ratio available for MS, and a thermal desorption system replaces the laser. An accuracy of better than 20% in concentrations is envisaged; of course, this improvement is at the expense of individual particle resolution.

In situ chemical and physical analysis of aerosol particles remains a challenging scientific task. As Spurny wrote in 1986 (*11*, p. 5), "Nevertheless, this is a realistic dream which might be fulfilled before the end of our century."

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Refining the Taxonomy of Memory

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Memory has a distinct taxonomy, with its various forms defined by their nature and time course. The classifications of memory have long been debated by cognitive psychologists, but some of the clearest evidence comes from the study of a famous patient with epilepsy, known by his initials as H.M. Because of the severity of his epilepsy, the medial temporal lobes of H.M.'s brain were removed to prevent nearly constant seizures. As a result of this neurosurgery, H.M. is profoundly impaired in the acquisition of certain forms of information. He cannot consciously recollect new events in his life or new facts about the world, a form of memory that has been labeled "declarative memory." However, H.M. (and similar patients) retain the ability to remember other types of information. For example, H.M. can learn new visuomotor skills—such as reading in a mirror after several practice sessions—even without awareness of having been tested previously. The selectivity of H.M.'s amnesia suggested the existence of two forms of learning and memory—declarative and skill—presumably governed by different neural systems that can operate in parallel on the same input. A report in this issue by Knowlton *et al.* (*1*) strengthens the distinction between different forms of memory and describes a double dissociation: A pattern of deficits similar to those of H.M. in patients with amnesia and a pattern complementary to that of the amnesics in patients with Parkinson's disease, a neurodegenerative disorder leading to loss of dopamine from the striatum (Fig. 1). The patients with Parkinson's disease have impairments in nondeclarative memory, but their declarative memory is normal.

Previous attempts to show deficits for various forms of skill learning and intact declarative memory in patients with Parkinson's disease have foundered, because such patients often have globally impaired performance and because there is variability in determining the extent (and therefore the exact brain lesion) of the disease. Likewise, it has proven difficult to obtain unequivocal evidence from functional brain imaging studies of normal individuals that structures such as the striatum are selectively utilized when skills are learned. The successful approach now reported by Knowlton *et al.*

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