Mass spectrometric investigations of the atmospheres of giant planets

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Abstract

The chemical and isotopic composition of giant planets is diagnostic of their formation and evolution history. Measuring their heavy element, noble gas, and isotope abundances reveals the physico-chemical conditions and processes that led to formation of the planetesimals that eventually fed the forming planets.
Our present, rather limited, knowledge of Uranus' and Neptune's composition is derived from flybys by the Voyager 2 spacecraft in 1986 and 1989, respectively, and from remote sensing from Earth-based observatories and space telescopes (see review by Mousis et al. 2018). The Uranus and Neptune atmospheres are primarily hydrogen and helium, with significant abundances of noble gases and isotopes. With the exception of methane, remote sensing observations have never been able to detect the key volatile species (NH3, H2S, H2O) thought to comprise deep ice giant clouds, and a host of minor species remains undetected. Such measurements can only be performed in situ from an atmospheric entry probe.

The chemical and isotopic composition of Uranus' and Neptune's atmospheres, and their vertical profiles in the atmosphere, will be measured by mass spectrometry. The scientific objectives relevant to the planets' formation and the origin of the solar system requires in situ measurements of the chemical composition and isotope abundances in the atmosphere, such as H, C, N, S, P, Ge, As, the noble gases He, Ne, Ar, Kr, and Xe, and the isotopes D/H, 13C/12C, 15N/14N, 17O/16O,18O/16O, 3He/4He, 20Ne/22Ne,38Ar/36Ar, 36Ar/40Ar, and those of Kr and Xe, of which very little is known at present.
The presentation will be focussed to the discussion of *in situ*measurements by mass spectrometers on atmospheric probes. Such instruments are very versatile, are able to measure quantitatively the abundance of any species over large dynamic range, and allow for isotopic measurements. Mass spectrometer capabilities can be augmented by the addition of enrichment cells (e.g. for noble gases), with chromatographic columns for chemical pre-separation, with aerosol collectors and pyrolysers, and others. We will review the state-of-the-art in this field and summarise possible future directions of instrumentation for atmospheric entry probes.

Keywords: Composition, Atmospheric profiles, Isotopes, Mass spectrometry

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