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Non-equilibrium chemistry in outer Solar System atmospheres

Bruno Bézard
Observatoire de Paris, LESIA, CNRS, Meudon, France (bruno.bezard@obspm.fr)

Planetary and satellite atmospheres are subject to various disequilibrium processes that strongly affect their chemical composition. These include photochemistry and electron-induced chemistry, shock chemistry from cometary impacts, and transport of species from deep hot levels where they are thermodynamically stable. These processes produce molecules and aerosols that enhance the chemistry at work in the upper atmosphere, contribute to the radiative budget and can also be used as tracers of the atmospheric dynamics.

The Cassini-Huygens mission has provided invaluable information on the atmospheric chemistry of Titan and demonstrated the complex interplay between gas phase chemistry, aerosol formation and evolution, radiative energy budget and dynamical transport. The horizontal and vertical distributions of the detected species and aerosols, combined with the temperature field, allowed us to monitor the main features of the seasonally-varying global circulation. In the giant planets, shock chemistry from cometary impacts is a significant source of non-equilibrium gases in their upper atmospheres. Several long-lived species created by the Shoemaker-Levy 9 collision with Jupiter in July 1994 provide a unique means of monitoring the atmospheric transport in the stratosphere. In addition, some compounds, stable at deep atmospheric levels, are transported by turbulent mixing to the colder observable atmospheres where their chemical conversion is kinetically inhibited. These non-equilibrium species convey in principle unique information on the deep atmospheric mixing in the giant planets and on the bulk elemental composition. This is also true for giant exoplanets where a few non-equilibrium species have already been observed and many more detections are expected from upcoming observing facilities.

These are examples of non-equilibrium chemistry in planetary atmospheres, essentially revealed by remote sensing infrared spectroscopy, that I will discuss in this talk.