Physical Sciences

Turbulence and the Stabilization Principle

NASA's Jet Propulsion Laboratory, Pasadena, California

Further results of research, reported in several previous *NASA Tech Briefs* articles, were obtained on a mathematical formalism for postinstability motions of a dynamical system characterized by exponential divergences of trajectories leading to chaos (including turbulence).

To recapitulate: Fictitious control forces are introduced to couple the dynamical equations with a Liouville equation that describes the evolution of the probability density of errors in initial conditions. These forces create a powerful terminal attractor in probability space that corresponds to occurrence of a target trajectory with probability one. The effect in ordinary perceived three-dimensional space is to suppress exponential divergences of neighboring trajectories without affecting the target trajectory. Consequently, the postinstability motion is represented by a set of functions describing the evolution of such statistical quantities as expectations and higher moments, and this representation is stable.

The previously reported findings are analyzed from the perspective of the authors' Stabilization Principle, according to which (1) stability is recognized as an attribute of mathematical formalism rather than of underlying physics and (2) a dynamical system that appears unstable when modeled by differentiable functions only can be rendered stable by modifying the dynamical equations to incorporate intrinsic stochasticity.

This work was done by Michail Zak of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-45937

Improved Cloud Condensation Nucleus Spectrometer

Droplets can be sampled over a wide range of supersaturations in a short time.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved thermal-gradient cloud condensation nucleus spectrometer (CCNS) has been designed to provide several enhancements over prior thermal-gradient counters, including fast response and high-sensitivity detection covering a wide range of supersaturations. CCNSs are used in laboratory research on the relationships among aerosols, supersaturation of air, and the formation of clouds. The operational characteristics of prior counters are such that it takes long times to determine aerosol critical supersaturations. Hence, there is a need for a CCNS capable of rapid scanning through a wide range of supersaturations. The present improved CCNS satisfies this need.

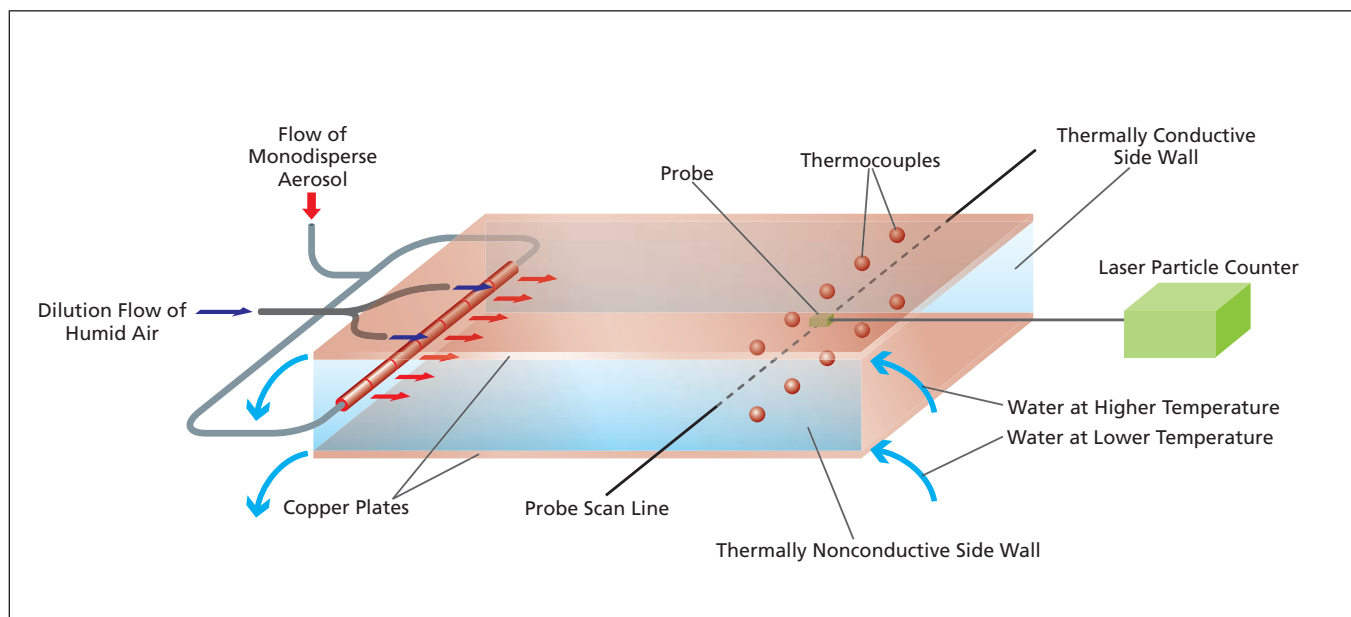The improved thermal-gradient CCNS (see Figure 1) incorporates the following notable features:

Figure 1. In the **Improved Thermal-Gradient CCNS**, a gradient supersaturation field is established in the main chamber. The probe is moved along the width axis to sample droplets over a range of supersaturations.
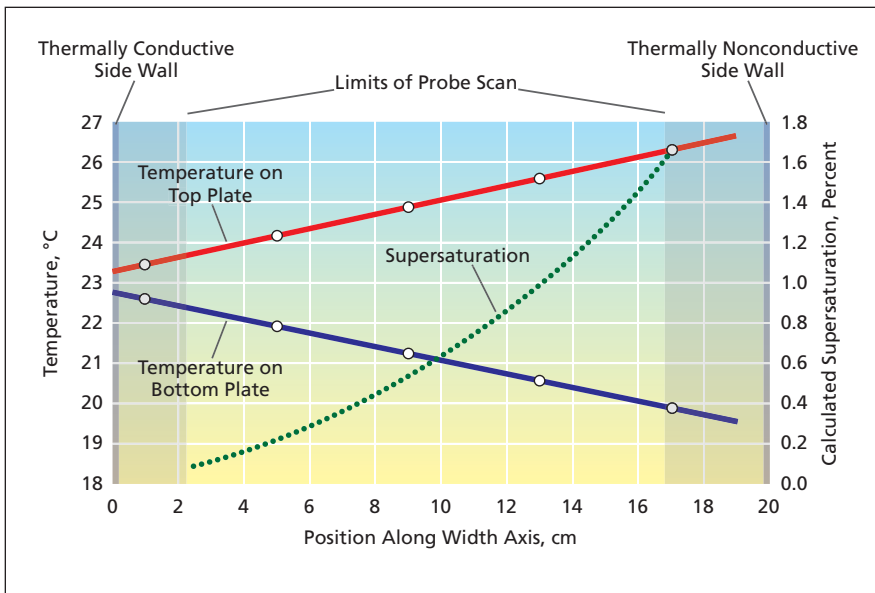
Figure 2. **Straight-Line Fits to Temperature Readings** of top- and bottom-plate thermocouples were used to calculate the supersaturation as a function of position along the width axis of the chamber.

- The main chamber is bounded on the top and bottom by parallel thick copper plates, which are joined by a thermally conductive vertical wall on one side and a thermally nonconductive wall on the opposite side.
- To establish a temperature gradient needed to establish a supersaturation gradient, water at two different regulated temperatures is pumped through tubes along the edges of the copper plates at the thermally-nonconductive-wall side. Figure 2 presents an example of temperature and supersaturation gradients for one combination of regulated temperatures at the thermally-nonconductive-wall edges of the copper plates.
- To enable measurement of the temperature gradient, ten thermocouples are cemented to the external surfaces of the copper plates (five on the top plate and five on the bottom plate), spaced at equal intervals along the width axis of the main chamber near the outlet end.
- Pieces of filter paper or cotton felt are cemented onto the interior surfaces of the copper plates and, prior to each experimental run, are saturated with water to establish a supersaturation field inside the main chamber.

- A flow of monodisperse aerosol and a dilution flow of humid air are introduced into the main chamber at the inlet end. The inlet assembly is designed to offer improved (relative to prior such assemblies) laminar-flow performance within the main chamber. Dry aerosols are subjected to activation and growth in the supersaturation field.
- After aerosol activation, at the outlet end of the main chamber, a polished stainless-steel probe is used to sample droplets into a laser particle counter. The probe features an improved design for efficient sampling. The counter has six channels with size bins in the range of 0.5- to 5.0-μm diameter.
- To enable efficient sampling, the probe is scanned along the width axis of the main chamber (thereby effecting scanning along the temperature gradient and thereby, further, effecting scanning along the supersaturation gradient) by means of a computer-controlled translation stage.

Better Modeling of Electrostatic Discharge in an Insulator

A model based on Kohlrausch relaxation gives improved fits to experimental data.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved mathematical model has been developed of the time dependence of buildup or decay of electric charge in a high-resistivity (nominally insulating) material. The model is intended primarily for use in extracting the DC electrical resistivity of such a material from voltage-vs.-current measurements performed repeatedly on a sample of the material over a time comparable to the longest characteristic times (typically of the order of months) that govern the evolution of relevant properties of the material. This model is an alternative to a prior simplistic macroscopic model that yields results differing from the results of the time-dependent measurements by two to three orders of magnitude.

The present model is based on the Kohlrausch relaxation law, named after its author, who first reported a long-lasting dielectric relaxation in 1854. Since then, the Kohlrausch law has been used to describe a myriad of physical phenomena. Kohlrausch relaxation is also known as stretched exponential relaxation because the time-dependent value of a Kohlrausch-relaxing quantity of interest is proportional to the stretched exponential function $\exp[(-t/\tau)^{\beta}]$
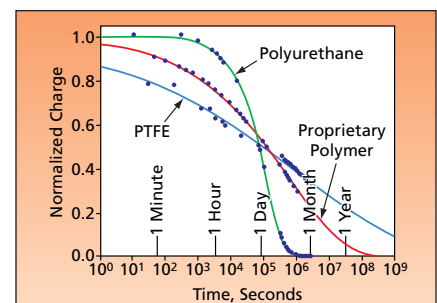
Kohlrausch Fits (the solid curves) were made to normalized-charge data calculated from long-term measurements on three different dielectrics: a poly(tetrafluoroethylene) [PTFE], a polyurethane, and a proprietary polymer.